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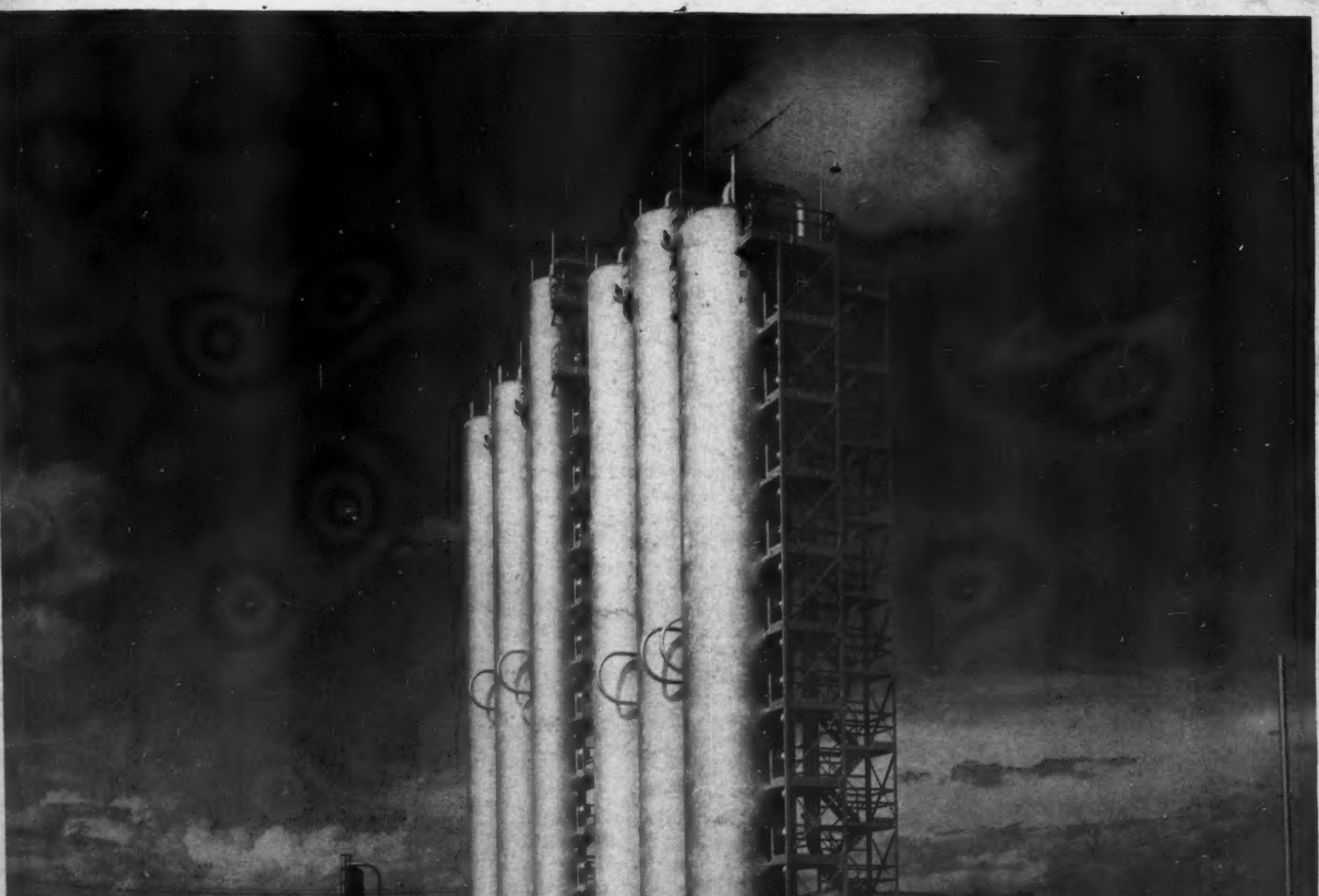

A TEXAS GASOLINE PLANT

ON THE COVER

ONE OF the problems of the natural gasoline producer is to tame "wild" gases. This is done in stabilizers—tall towers in which volatile elements are brought into a state of equilibrium. Our cover picture shows the stabilizers of a modern Gulf Coast refining plant.

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IN THIS ISSUE

SUGAR, the very name of which connotes sweetness, is to most of us an indispensable food. "From Cane to Table" describes a long and interesting journey that has much to do with man's after-dinner physical contentment.

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COMPRESSED air illness is no longer the dreaded scourge of pressure workers that it was when Brooklyn Bridge was built. Continued scientific research is revealing much information of inestimable practical value to divers and subaqueous construction men. In this issue, developments in that important field of study are brought up to date.

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SAFETY in an air compressor plant can be assured by following a few fundamental rules, and by exercising sound judgment and reasonable care. Every industrial plant engineer will benefit from the authoritative article that starts on page 5445.

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METAL mines are rapidly adopting the scraper or slushing method of loading ore underground. "Scraper Loading Aids Joplin Mines" is a non-technical description of the process that points out some of its advantages over conventional loading practices. It was written for the Miami (Okla.) News-Record and is reprinted with the permission of the author.

Compressed Air Magazine

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EDITORIAL CONTENTS

ADVERTISING INDEX

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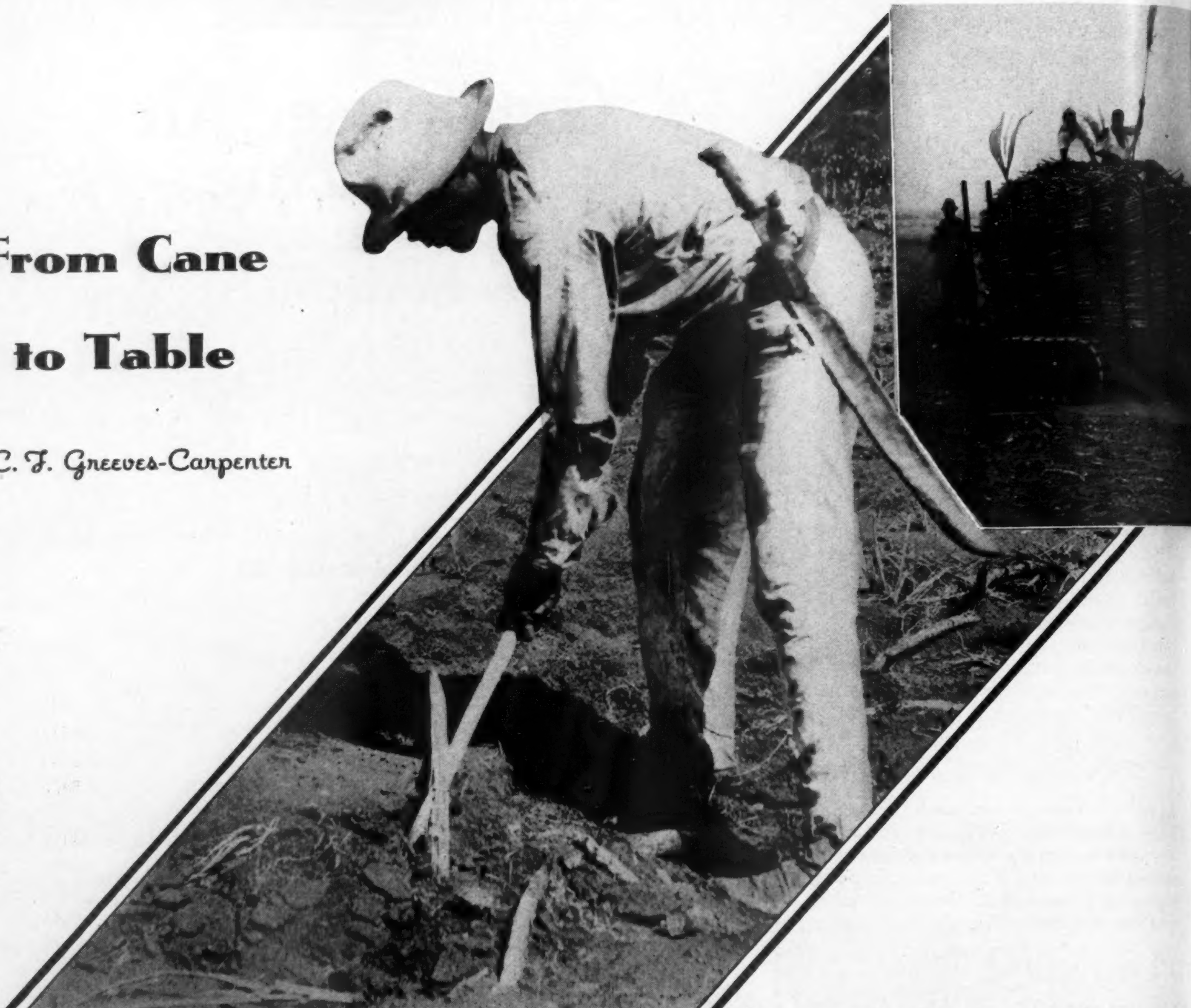
From Cane to Table

C. J. Greeves-Carpenter



PLANTING OPERATIONS

After testing the soil to make sure that it is suitable for growing sugar cane, the land is cleared, then plowed and harrowed with implements drawn by steam-powered tractor. The seed consists of the "eyes," which are the tassel-like tops of mature cane. After a crop is harvested, new shoots will spring up from the roots or "ratoons" that are left in the ground. About every third or fourth year, however, additional "eyes" are set out. The upper view shows a workman making a hill ready for planting. Hanging from his belt is a long-bladed machete that is used to cut down mature cane.

IT IS fascinating to speculate on the events which led to the finding of sugar, and on what would have happened had the world been deprived of this ingredient. Aside from its beneficial effect on our bodily system, sugar has done much to stimulate agriculture and general business. The candy and confectionery trades would probably be non-existent without it.

To the Macedonian soldiers of Alexander the Great belongs the credit of having found the "honey-bearing reed" on the banks of the Indus in India, about 300 B.C. A hundred years afterward some caravans transported some of the reed to China, but it was not until still some 700 years later, about 500 A.D., that the first shipment of crudely refined sugar was transported from India to Europe. In the Middle Ages, according to historians, Egypt produced by far the best sugar and even today in India coarse sugar is known as "Chinese," while the fine grade is termed either "Cariene" or "Egyptian." The Egyptians early developed large plantations and a simple process for the purification and recrystallization of sugar. It is known that they remelted the first crystals and added albumen and lime

GATHERING THE CROP

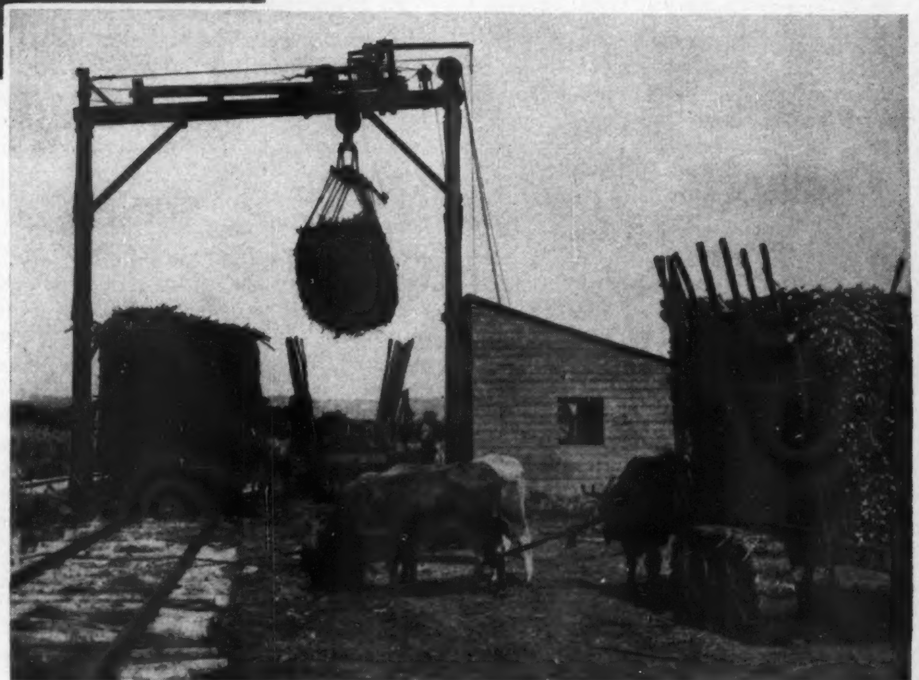
After being harvested, the cane is cut into lengths convenient for handling and loaded into carts which are drawn to the railroad by either tractors or ox teams. It is then transferred into cars and moved to the mill or "central," where it is processed for extraction of the raw sugar. The United Fruit Company operates 340 miles of railroad in Cuba to facilitate the haulage of cane to its two mills.

to the solution. All the precipitated impurities were removed by filtration, and the resulting clear syrup was boiled down to grains. The syrup in which these grains were left was eliminated by washing, and only the fine white sugar crystals remained.

In 1493, Christopher Columbus brought some sugar cane on his second voyage to the Western Hemisphere, and it was planted in the West Indies but the first attempts to grow it there were not successful. With the introduction of Negro slaves, sugar planting took on a new lease of life and flourished. It was not until 1751, however, that sugar cane reached the North American mainland, being brought into Louisiana from Santo Domingo by the Jesuit Fathers.

The cane sugars used on this continent come from several sources. Cuba, Puerto Rico and the Philippines send their sugars to Atlantic and Gulf ports. Sugar from the Hawaiian Islands is shipped to San Francisco. Then, of course, Louisiana produces a small amount of cane sugar, averaging a little more than 335,000 long tons annually. The methods of growing, harvesting, processing and refining are practically identical in all basic principles.

Sugar is derived from sugar cane, sugar beets and sugar maple trees. These have been mentioned in the order of their importance as producers of sugar. While this article is designed to cover all phases of sugar production from sugar cane, it may be of interest to mention briefly some facts about beet and maple sugar. The sugar beet is comparatively small, but by a process of selection and development it has been possible to extract from it as high as 25 per cent of sugar, though the average yield is nearer 14 per cent. On this continent its production is largely confined to the central and western sections of the United States and to Ontario in Canada. Their annual production of beet sugar averages approximately 1,342,000 short tons.



Maple sugar is a product of the sugar maple tree, a close relative of the common maple. The production of sugar from this source is confined to Canada, New England and the Great Lakes section, and approximates 4,100 short tons a year.

The commercial production of cane sugar is practically limited to the tropical belt of the world. The Hawaiian Islands yield an average of 980,000 short tons per year, the Philippines 1,200,000 short tons. Cuba, the British West Indies and Puerto Rico jointly yield, in an average year, 4,222,000 short tons.

In Cuba, the United Fruit Company owns some 90,000 acres devoted to cane growing and has an additional acreage of undeveloped but suitable land in which cane could be successfully grown. In addition, the company owns 340 miles of railway which is operated in connection with its sugar interests. Two large mills or "centrals," having an average daily grinding capacity of 7,000 tons of cane, have been erected at Boston, Cuba and Preston, Cuba. They are jointly capable of producing 350,000 tons of raw sugar annually.

Only a very small proportion of cane sugar is refined in the country of its origin, so a subsidiary company, the Revere Sugar Refining, operates at Charlestown, Mass., a refinery which has a daily output of 1,000 tons of refined sugar. The Revere refinery has its own docks to which the sugar fleet brings the raw sugar from the centrals in Cuba as well as raw sugar purchased from the Philippines, Hawaiian Islands and Puerto Rico. The three countries last mentioned pay no tariff on raw sugar shipped into the United States. This, plus cheap labor, makes it very attractive partially to process sugar in the Latin-American countries and that is the general practice. At present there is a congressional bill drafted to allow these countries to ship in refined instead of raw sugar duty free, and if it is passed it is claimed that the American cane sugar refinery industry will be doomed within a year and about 20,000 wage earners added to the unemployed.

Land deemed suitable for a sugar cane plantation is thoroughly examined before preparations for its cleaning and planting are commenced. It is then surveyed and laid out in sections which facilitate efficient working as well as the maintenance of production and cost records, so that accurate figures are available on each section at all times. Virgin land naturally has to be cleared of trees and underbrush. Hard timber is saved for utilization in building houses, etc., for the employees, but the remainder is felled and allowed to dry out. Preceding planting operations, the land is burned over and then plowed by steam-powered tractor or by bull-drawn plow in the case of the smaller plantations. Plowing is followed by thorough harrowing to pulverize the soil as much as possible.

Wide fire lanes are established along railroad tracks and these are usually planted with some succulent, green vegetable as, besides furnishing food, such planted areas tend to prevent the adjacent growing cane from being fired by flying sparks from locomotives.

Coincident with this work of clearing land, buildings are constructed for the housing of employees, a hospital is built, the central, or sugar factory is constructed, a clubhouse is provided, and all the other structures which make for the satisfactory and complete operation of the plantation are erected.

Sugar cane, *saccharum officinarum*, is a member of the grass family which, under ideal growing conditions, attains a height up to 20 feet. The height, though, is a variable quantity, dependent upon several factors such as the fertility of the soil, the amount of rainfall during the growing season, the number of times the field is cultivated, as well as the number of crops which have been harvested from the same soil. While it grows best on the lower levels, cane may also be profitably cultivated at altitudes up to 4,000 feet.

The plant is composed of roots, stalk, leaves, and flowers or tassels. The slender roots vary up to three feet in length and spread out laterally in the ground. Several shoots will grow from one root, forming a stalk. The shoots or canes are made up of a number of sections, usually four or five inches long and these are joined by nodes from each of which a single, long, narrow leaf, resembling the foliage on corn, will grow. These leaves drop off as the cane matures. At the top of the cane is a cluster of long, slender leaves in the center of which is a single stem bearing the flower, a large reddish-gray tassel.

Internally the cane is composed of a number of fibrous strands through which the principal life processes of the plants are conducted. Actually the strands serve as channels which conduct the moisture and plant food in the soil to the leaves. It is in these leaves, the chemical laboratories of nature, that the early stages of the development of the sucrose, which later becomes the sugar as we know it, takes place. The action of the sunlight forms carbohydrates, and these pass from the leaves to the stalk and are converted into sucrose in the pith or open cellular structure within the cane. It has been established that the cane usually averages about 87 per cent juice and 13 per cent fiber, but this is only an average percentage, as naturally the amounts of both juice and fiber are dependent upon the conditions under which the cane has been grown in any particular season.

The tops of harvested mature canes, which are merely the "eyes," are planted and from these new shoots grow. Later crops spring from the roots or ratoons which are left in the ground when mature cane is harvested. Fresh "eyes," though, are set out every third or fourth year, and then the process of production from ratoons again proceeds for another three or four years.

Under usual conditions, the cane stalks will start to show above ground about two weeks after the eyes are planted. The first crop, termed the "plant cane," requires from a year to fifteen months to mature. When this is harvested, new shoots develop from the rootstock and these form the second crop or "first ratoons," as they are termed on the plantation. The second crop usually matures in a year, but whenever practical from the standpoint of mill requirements, it is allowed up to eighteen months in which to grow as, from experience, it has been found that the cane then yields more sucrose.

Harvesting is not undertaken until polariscopic tests show that a satisfactory amount of sucrose is present. No method has yet been developed which will cut and garner the cane by machinery; consequently this is all done by hand labor. Negro workers, armed with machetes, methodically cut the cane close to the ground. The leaves which may still adhere are removed from each stalk and, together with the green tops, are left lying on the soil, as they aid in holding moisture in the ground, help

SEED CANE

Sugar cane is classed as a member of the grass family, but it has some of the structural features of bamboo. Here are segments of cane that have been cut for planting.

to retard the growth of weeds, and also form shade for the young stalks which soon develop from the rootstock. The cane itself is cut into suitable lengths for loading on to carts drawn by oxen or tractor. These are then hauled to the railroad siding and weighed, as it is by weight that the cutters are paid. The cane is then loaded on to freight cars and transported to the central.

Five distinct operations are necessary in the mill for the production of raw sugar. First, however, the cane is weighed and is then placed on a conveyor which hoists it to the top of the building where it is fed into giant crushers. Each crusher consists of two long steel drums about 36 inches in diameter with deep horizontal interlocking criss-crossed furrows on their surfaces. From nine to eighteen roll mills, as the crushers are termed, are operated in units of three and under a progressively rising pressure ranging between 250 and 400 tons. The top roll of each unit is so operated that it rises and falls with the variation in feeding of the cane. The rolls make only about three complete revolutions per minute, as by slow grinding a maximum of juice is extracted. Either hot or cold water, or in some mills diluted juice, is sprayed on the cane mass, usually in front of all the units except the first. This helps to free any sucrose residue which might otherwise remain in the cells or pith. By the time the cane has passed the last unit it is a mere mass of fibrous tissue, from which practically all the juice has been extracted or crushed. The "bagasse" or fibrous mass is then automatically fed to the furnaces which operate the central.

The breaking up of the cane and the extraction of the juice comprise the first operation in the central, but the juice contains impurities such as gums, glucose, inorganic salts, fine cane tissue, etc., which are held in suspension. If allowed to remain in the juice, they would tend to prevent crystallization, and the extraction of the crystals from the syrup in the final operation. The juice, too, is turbid and greenish in color and the next operation, therefore, entails its purification and clarification. It is treated with lime to neutralize the acids in it, as well as to cause a partial precipitation of the chemical impurities. Unless the chemical action, which would otherwise quickly take place in untreated juice, were thus arrested by neutralization, fermentation would result. The neutralized juice is then passed by gravity flow through strainer plates into long tubular heaters in which the temperature is brought to a point a little below boiling. It is then pumped through a series of large tanks or defecators in which live steam brings the juice up to the boiling point. The combined action of the lime and the heat causes a coagulation of the impurities. The heavier compounds settle to the bottom and the lighter ones rise to the surface and form a scum. The clear juice is drawn off and is passed to the evaporators. All the impurities left in the defecators are washed into scum tanks in which the mass is heated and allowed to settle, and the clear juice which rises to the surface is then also passed to the evaporators. In multi-effect vacuum evaporators approximately 65 per cent of the moisture in the juice is evaporated off, and the resulting concentrated syrup is of thick consistency and brownish in color. The settled impurities in the scum tanks form mud or filter-press cake, as it is called. This is processed to extract as much juice as possible. The residue is then utilized in the fields as fertilizer.

From the evaporators the syrup is passed to storage tanks from which it is transported as needed to vacuum pans in which it is boiled by steam. When the syrup has boiled down to a density of about 88° Brix, grains or crystals commence to form. The crystals, however, after this processing, are not free of syrup so the fifth and last major operation at the central consists of separating the grains or crystals from the syrup or molasses.

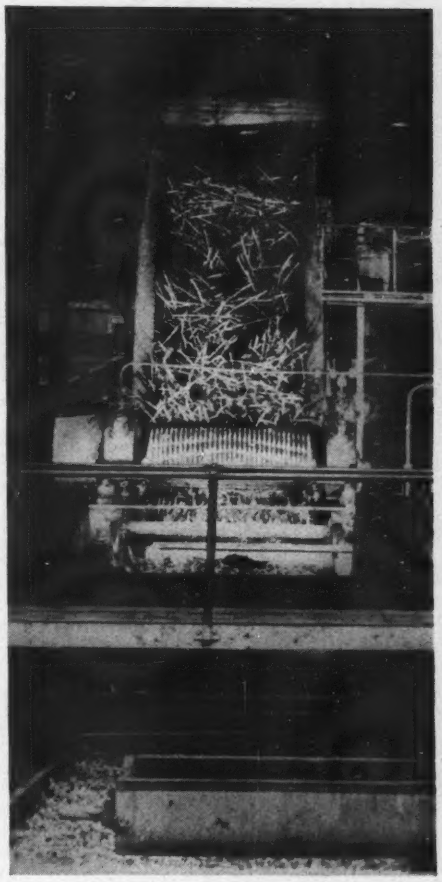
The whole mixture of crystals and molasses, or "magma" as it is termed, is dropped into mixing tanks which feed into centrifugal machines on a lower floor level. In these latter, under centrifugal force, the sugar grains are separated from the molasses, and are golden brown in color. This sugar is approximately 96 per cent pure, and is ready for shipment to the refinery on the mainland.

In order to reduce losses in the processes of production of sugar from the sucrose in the cane as far as possible, strict chemical and weight supervision is maintained at every point from the extraction to the final clarification and crystallization of the raw sugar. It is roughly estimated that it takes about 8½ tons of cane to produce one ton of crystals.

With all the processing the cane and sucrose receive at the central, one unfamiliar with sugar might quite reasonably ask: "Why do the golden-brown sugar cystals require any further processing?" It is necessary for a very definite reason: in the refining of the raw sugar, the remaining impurities together with any foreign substance and color are removed. The refined product is pure, of high food-energy value, and of excellent keeping quality.

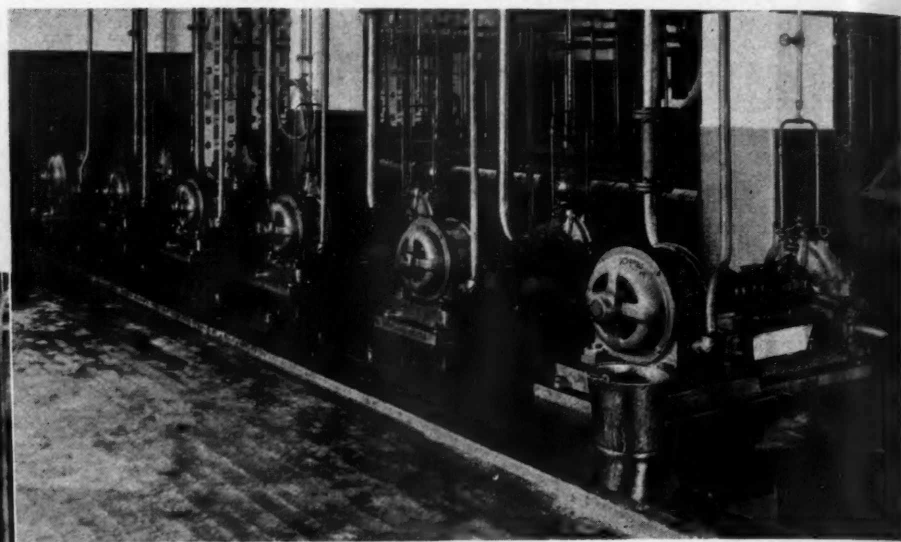
The United Fruit Company operates a sugar fleet of four modern oil-burning steamships in addition to its banana and passenger ships. The sugar vessels were originally designed to have a capacity of 24,000 bags of raw sugar but recently an elevator conveyor has been devised which makes possible the discharge of bulk sugar. This not only obviates the necessity of bagging, but considerably facilitates both the loading and unloading of the raw sugar and is an entirely new departure in the transportation of sugar. Each of the holds has a capacity of 2,300 tons of raw sugar.

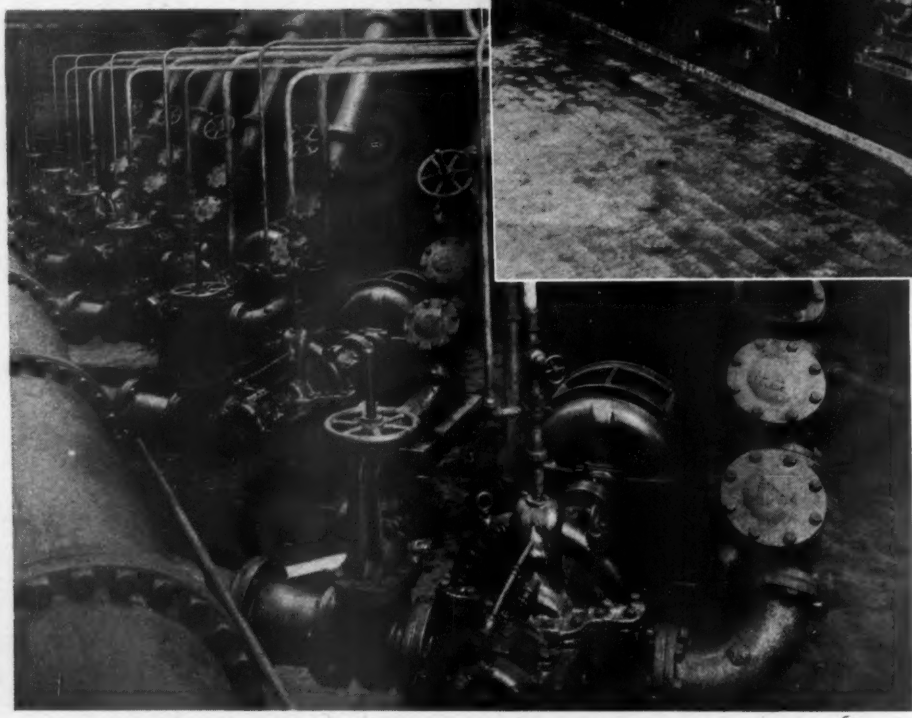
Upon arrival at the refinery dock, an endless chain bucket elevator is swung into position and supported by the ship's boom over the hold to be unloaded. As the unloading proceeds, the elevator is lowered deeper into the hold, until it finally rests on the hull of the vessel. The sugar is fed, through gratings, to the bottom of the elevator by two large bottomless scrapers, which are moved by cables, in dragline fashion, back and forth across the mass. These cables are operated by two Ingersoll-Rand 50-hp., double-drum, electric "Tugger" hoists. The operation is analagous to the "slushing" process of loading ore in mines. The elevator handles from 200 to 250 tons an hour and delivers the sugar to a 36-inch belt which transfers it into the refinery directly to storage hoppers having a capacity of 20 tons each. The hoppers are equipped with air-operated gates powered by a 5x5-inch I-R air compressor, and empty into a scale hopper which is operated by a Government inspector. The scale hopper holds about 12 tons of sugar and discharges its contents on to a 60-inch con-



ROLL MILLS

The tangled mass of cane stalks, resembling large jack-straws, is fed between revolving metal drums with criss-crossed interlocking furrows on their surfaces. These turn slowly, crushing the cane and liberating its contained, sugar-bearing juice. After passing through three sets of rolls and being subjected to pressures that progressively increase from 250 to 400 tons, the woody structure is reduced to a fibrous mass. This residue, termed "bagasse," is fed to the boiler fireboxes of the mill.





SOME OF THE PUMPS

A sugar refinery requires many pumps. Here are some that have served the Revere Refinery for many years. The lower picture shows six Cameron DV units that pump salt water to four steam condensers. Four are operated at a time, with two as spares. Each unit is driven by a 50-hp. motor and is rated at 875 gpm. against 140 feet head. At the top are six other Cameron DV units that distribute different grades of sugar liquor to various tanks.

veyor belt which in turn transfers the sugar to a central point on the bottom floor of the raw sugar storage warehouse. This warehouse has a capacity of 23,000 tons. It is then weighed on electric automatic platform scales, first by the Government representative and, in the case of sugar purchased from independent growers, by the seller's representative. It is then picked up by scoops for storing or is moved by an elevator and overhead conveyors direct to the refinery for processing.

The fundamental principles governing the refining of raw sugar are comparatively simple, but the actual operations involved are rather complex. Refining raw brown sugar to cube, finely granulated or powdered white sugar involves many processes and the final products must conform to rigid specifications. Moisture and color tests are made of each sample, and ash and acidity determinations have to be made so that the actual degree of purity of the product may be ascertained and recorded. Luster, structure and crystal size also enter into the final grading, and these features are checked by both screen analyses and by microscopic examination.

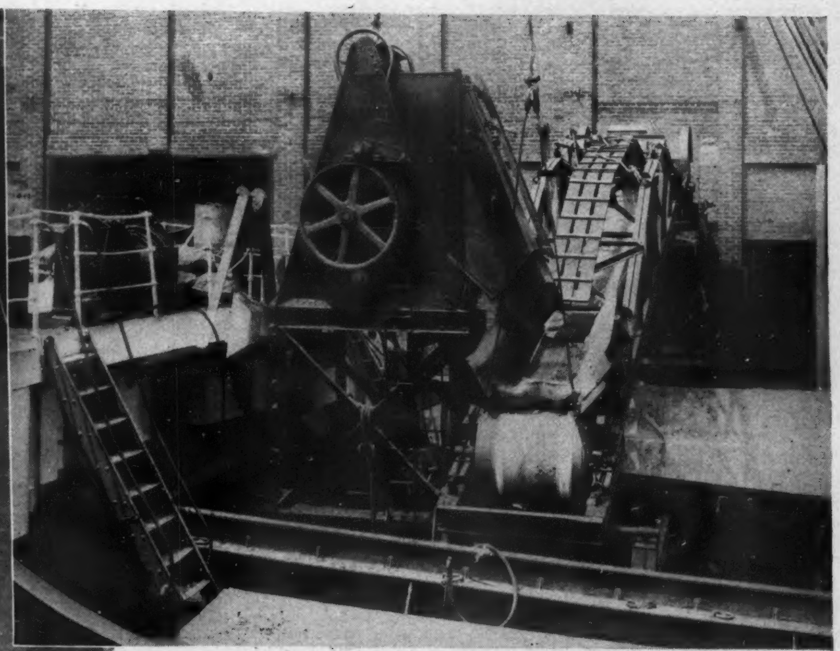
The refining processes are continuous from the time the raw sugar enters the melt until it is finally packaged. The laboratory plays an extremely important rôle in this production of refined sugar as every process is carefully tested by chemical analysis.

The refining processes may be divided into four classifications: 1—The melt, in which are involved dumping the raw sugar, mingling, purging, washing and melting it to a liquid state; 2—filtration, in which the liquid undergoes clarification and bone-char filtration; 3—crystallization of the sugar liquid, the separation of the crystals from the liquid and their drying; 4—drying, screening and grading the crystals, and packaging them for shipment.

In the melt house, the raw sugar is first passed to "minglers," in which it is thoroughly mixed with syrup which, being a saturated sugar solution, does not dissolve the raw sugar as would ordinary water. This process softens the film of molasses which adheres to the surface of the crystals from the last operation at the central. The mixture, or "magma," resembles a soft brown mortar and this is dropped into centrifugals on the floor below for washing. These centrifugals are operated at 1,200 rpm. and have a capacity of approximately 1,226 pounds. The centrifugal force causes the magma to rise around the inside wall of the "basket" and at the same time throws off through the perforated and screened sides all the syrup which was previously added. The raw sugar remains in the machine and is then sprayed with from 4 to 8 pounds of hot water under high pressure. This operation washes the faces of the crystals, carrying off not only most of the impurities but a certain amount of sugar which has been dissolved. Roughly estimated, only about 710 pounds of washed sugar remains out of the original 1,226 pounds of magma.

This, however, does not indicate a loss of sugar, for the water which has washed the first batch is now a syrup and in that form is drawn from the centrifugal machines and a portion of it is pumped to the floor above to mix with more incoming raw sugar. The rest of it is boiled in vacuum pans into raw sugar crystals. The syrups separated from these crystals have a low sugar content, and are sold as black strap, to produce alcohol. In this first refining process, the degree of purity of the still raw sugar has been raised to 99.2 per cent.

From the centrifugals, the washed sugar is dropped into "melting pans," on the floor below. These are cylindrical, 1,500-gallon capacity tanks with a revolving vertical shaft in the center which is equipped with horizontal paddles. These melting pans expedite the dissolving of the sugar in hot water, which is added in the quantity of approximately half the weight of the sugar. The resulting liquor, which has a density of 66 per cent solid matter, and which is of light amber to dark brown color, is pumped to the filter or "char" house, where it undergoes clarification and bone-char filtration.



UNLOADING RAW SUGAR

As processed in the centrals in Cuba, the sugar is about 96 per cent pure. This raw product is then shipped to the Revere refinery in Massachusetts for further purification. It was formerly bagged to facilitate unloading, but an ingenious mechanical arrangement now makes it more economical to handle it in bulk. The equipment consists of a vertical bucket-type elevator that is lowered into the hold by the ship's boom. This discharges on to a conveyorbelt above decks that carries the sugar directly into the refinery. As unloading proceeds the elevator is progressively lowered until it finally rests on the hull. Sugar is fed to the elevator by scrapers that are moved back and forth across the cargo by cables. These cables are wound on the drums of two double-drum, 50-hp. electric "Tugger" hoists and are passed around sheave wheels that are hung at suitable points. One cable pulls the scraper backward and the other pulls it forward. This loading method, which is analogous to the "slushing" process employed in metal mines, is shown directly above. The view at the upper right shows the top of the elevator and the receiving end of the conveyor belt running into the refinery. Within the building, the sugar is discharged into a weighing hopper, as illustrated at the right.

It is first sent to "blow-ups," in which its temperature and density are suitably adjusted for filtration. The "blow-ups" are cylindrical tanks of 2,500-gallon capacity, equipped with a steam coil. The steam raises the temperature of the mass to 176°F. and reduces its viscosity. Perforated pipes in the bottom of the vessels permit compressed air, supplied by an I-R 10x14-inch compressor, to be forced through the liquor and thoroughly agitate and mix it.

Lime and diatomaceous earth (Kieselguhr) are now added. They absorb some of the impurities, but their chief purpose is to form a porous coating or filtering medium against cloths in the pressure filters to which the liquor is pumped. These contain many filter elements through which the liquor is passed under 2 to 60 pounds pressure. Filtration extracts dirt and any other insoluble impurities and thus partially clarifies the liquor. From the first filters, the raw sugar syrup passes to char-filters for the removal of all soluble impurities and coloring matter.

The char used in the char-filters resembles charcoal in appearance but is made from the bones of animals. These are first chemically cleaned and purified, and are then finely ground so that the pieces will pass through an 8-mesh and remain on a 24-mesh screen. The grains are hard and porous. The bone-char loses its properties of purification after being in use for 24 or 36 hours at most. It then has to be thoroughly washed with hot water, dried and burned in vacuum kilns at a temperature of 1,000°F., before it is again fit for satisfactory service. The actual operation of bone-char filtration consists of percolating the liquor through the char-filters under 12 pounds pressure at a rate of 1,500 to 2,000 gallons per hour. Actually, the liquor is in contact with the bone-char for practically three hours.

Next in line for bone-char filtration are the syrups in which some of the sugar has been boiled. These are followed by the filtered wash syrup and so on. The final washing out of the filters yields merely diluted sweet water contaminated with impurities, which is diverted to sweet water tanks. The sweet water is concentrated in evaporators and the heavy syrup is boiled in vacuum

STEAM-JET VACUUM PUMPS

By evaporating the sugar liquors under a partial vacuum, the boiling point is reduced, with a consequent saving in fuel. The vacuum is obtained by using steam jets, which act on the principle of aspiration. Two of the jets are shown here. Each consists of a 2-inch primary jet, an intercondenser, a 2-inch secondary jet, and an aftercondenser.

pans, producing raw sugar crystals and a syrup that is sold for black strap.

After bone-char filtration of the sugar liquor, it is passed to vacuum pans, where it is evaporated at low temperatures ranging from 100°F. to 160°F. The "pans" are large cylinders 16 to 17 feet high, and from 10 to 12 feet in diameter, and have a capacity of 50 tons. In these, the liquor is boiled under vacuum from 80 minutes to three hours, the actual boiling time and the temperature being the controlling factors governing the size of the resulting crystals. One and one-half hours is required for boiling common granulated sugar; and approximately 25 tons is obtained from each boiling. A correspondingly longer period is necessary in the production of the larger crystals and of powdered forms of sugar.

The pure, refined sugar crystals now have to be dried and this forms the last stage in the processing. The sugar mass from the vacuum pans is dropped in the form of a heavy mortar into centrifugals, the action of which separates the sugar syrup from the crystals. These are then washed with a spray of water, partially dried by centrifugal force, and passed into cylindrical drums, known as granulators, for complete drying. Each drying unit, is composed of an upper and lower granulator, 30 feet long and 6 feet in diameter, and slightly inclined from the receiving to the discharging end. Each drum has a series of short narrow ledges with saw-tooth edges fastened to its inner surface. As the drum revolves, these carry the sugar to the top of the vessel, and it then falls to the floor. This movement continues with each revolution, and every crystal meanwhile gets the full benefit of hot air which is introduced into the top granulator after being drawn over steam coils.

The lower granulator is used for cooling the crystals. When the sugar is discharged from the upper drum into the lower one, it is dry and hot, and if packed in such a state, would soon become caked. A large fan draws filtered cool air through the lower granulator and this cools the sugar to about 70° to 80°F. The moisture content of the refined sugar varies from .005 to .01 per cent, too low to affect it.

Of course the refined sugar has to be sorted and packed. Sorting is done by screens which first pass the very coarse and then the smaller grains. Two different grades of powdered sugar are manufactured, one of which has to pass a silk cloth screen having 200 openings to the square inch, and the other 100 openings to the square inch.

The sugar to be packaged in 5- and 10-pound bags passes by conveyor to packing and sewing machines at which girls handle twenty-five 10-pound bags per minute. Then conveyor belts transfer the filled bags to a packing table at which three large sacks are suspended. Three men fill the sacks, ten 10-pound bags to the sack, and place them on a conveyor for transfer to a sewing machine which sews the sacks across the top and they are then automatically dropped through an aperture in the floor to the storage room. Packaged sugar is handled in much the same manner, except that the machinery involved not only packs the sugar in the boxes but seals the wrapper on the box.

Sugar is the basic raw material for practically every confection. Hard candies, fondants, fudges, caramels, nougats, marshmallows, gum goods, starch jellies, pectin and agar jellies, chocolate and chocolate coatings, icings and canned goods all call for sugar in one or more forms to give them sweetness, an attractive appearance, body, and moisture retention.

Sugar is used in confections either in solution or in crystalline form. Its quality is of special importance when employed in solution form. The rate of solution, behavior on boiling, and whether or not color development will take place during boiling should all be known about a sugar before it is employed in confectionery manufacture.

Crystalline sugar is used in the coating of gum drops, and for other similar "sanding" purposes. When so employed, the attractiveness of the final product is largely dependent upon the appearance and size of the sugar crystals. The confectioner is therefore governed to a great extent by "grist" or grain size, in selecting a sugar for any particular purpose.

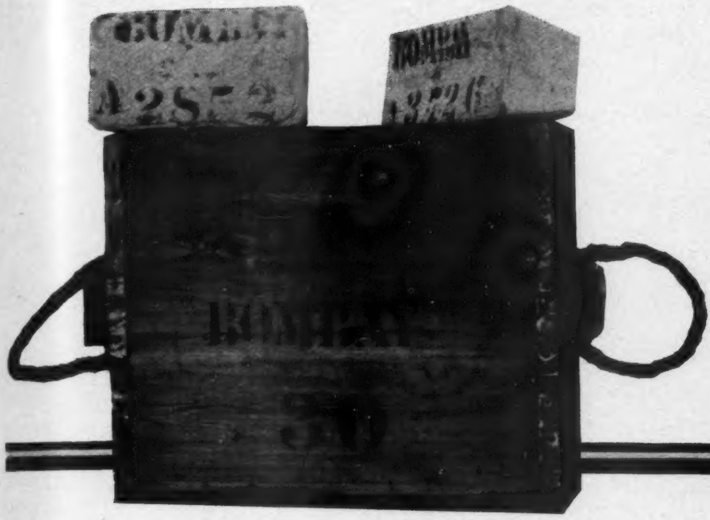
The trade name "confectioners sugar," as applied to certain grades of large-grained granulated sugar is misleading in that it implies that confectioners use such sugars exclusively. This is not the case as confectioners use nearly all the varieties of sugar produced by refiners and, as a matter of fact, probably use less of the so-called confectioner grades than of other kinds.

For certain purposes large crystals are desirable. In most markets there is available sugar in three different grain sizes ranging from relatively coarse crystals down to a grist used for sanding purposes. This sanding sugar is still not as fine grained as ordinary cane granulated, which is most universally used, not only for confections, but also for cooking and table uses. It is, in every sense of the word, a confectioners sugar, though it is not labeled as such.

Confectioners powdered sugar is a refined sugar that has been pulverized into particles of extremely small size. Large quantities of it are used in the making of icings, lozenges and coatings.

Brown sugars are used in large amounts because of their distinctive flavor and color, which lend themselves to many confectioner uses. Brown sugar is more than sugar of brown color. It is cane sugar that has been refined of all four substances found in raw sugar except certain desirable mineral salts and invert sugars (glucose) which give it an extremely agreeable flavor. There are three grades of brown sugar: light, medium and dark brown. Generally speaking, the darker the color, the higher the content of molasses and the stronger the flavor, so that it becomes somewhat a matter of taste which of these three sugars is selected for any particular use.

Of all the processed foods that enter into our dietary, it can be safely stated that none is more chemically pure nor more consistent in high quality than cane sugar, product of the "honey-bearing" reed.



TREASURE FROM THE DEEP
A diver going down to reclaim the contents of the strongroom of a liner sunk in deep and cold water, and a box of silver bullion recovered from the sea bed.

High Air and Deep Work

Robert G. Skerrett

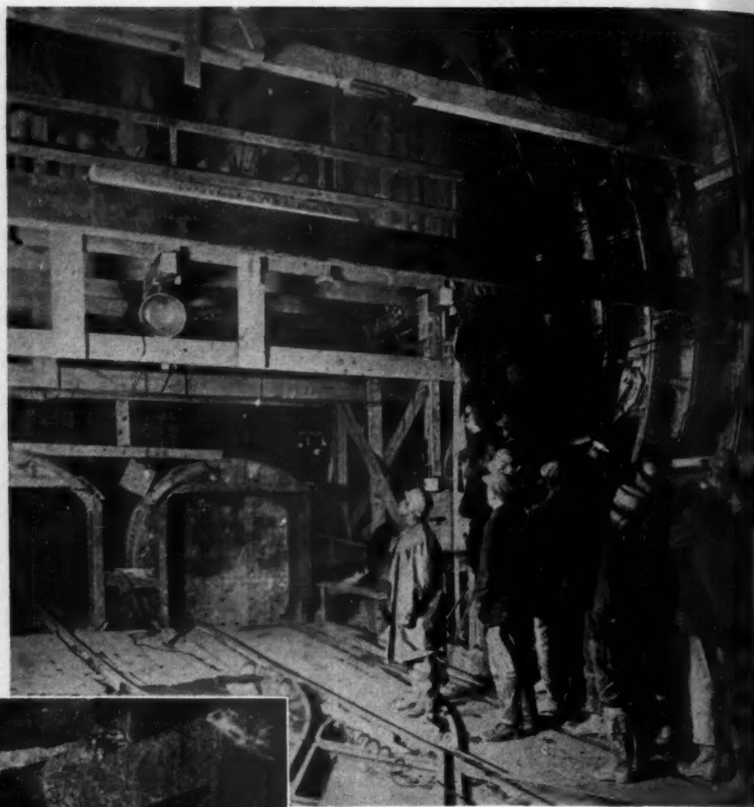
DIVERS may soon be able to descend underwater 400 feet and do there a goodly measure of useful work. Already, a diver wearing an up-to-date flexible dress, has descended 344 feet. What is equally important and suggestive, subaqueous tunnel drivers, caisson workers, and other allied toilers under compressed air are reasonably sure to be employed before long on engineering-construction jobs that heretofore have been deemed beyond the range of human effort.

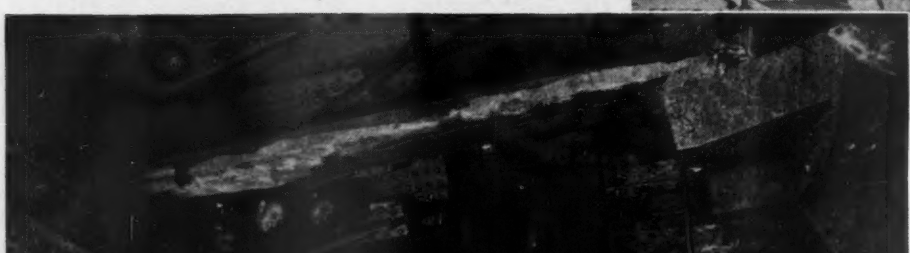
These prospects exist because extensive research and the development recently of improved apparatus have together profoundly altered the conditions affecting pressure workers. Helpful information has been gained from recurrent efforts to find ways to prevent or to lessen the likelihood of "bends" or any other maladies that may afflict the diver, and some of the advances represent the result of studies directed more particularly to improving the conditions under which subaqueous workers have to carry on. Step by step, physicians and specialists in compressed air work have been learning more and more about the human body and its astonishing capacity to meet physical stresses encountered under pressure. As a result of all these investigations, much has been done to lessen the risks the diver takes and to improve the circumstances under which he works; and these benefits will apply, in turn, to all pressure workers.

Nine years ago, we described what had up to then been done to reduce the likelihood of compressed-air illness among sand hogs, and reference was then made to the researches conducted by the deep-diving committee of the British Admiralty between 1905 and 1908. The outcome of those investigations led to the adoption of stage-decompression for divers and extended the safe working depth to 180 feet, although some of the men that made test dives actually reached the then unprecedented depth of 210 feet. Our own Navy, also bent upon improving the apparatus and methods in vogue in handling divers, brought into being changes that reached the climax in November, 1914, when Chief Gunner's Mate S. J. Drellishak descended 274 feet in the tide-swept waters at the eastern entrance of Long Island Sound. The next year, outside of Honolulu, some of our divers who helped to salvage the U. S. Submarine F-4 went down 306 feet in the open waters of the Pacific. That was recognized as a hazardous depth and was not again approached until the British Admiralty organized a second deep-diving committee to test the submergible decompression chamber devised by Sir Robert H. Davis, managing director of Siebe, Gorman & Company, Ltd., the well-known English concern that manufactures diving apparatus and equipment for underwater work.

The Davis submergible decompression chamber, as submitted to the committee, was the outcome of somewhat protracted development, and from 1931 well into 1933 it was put through a series of comprehensive trials before its adoption was officially recommended. Up to that time, the divers of the Royal Navy did not work deeper than 200 feet, but the chamber made it practicable for them to descend safely more than 300 feet and thus to permit the authorities to fix the maximum working depth at 300 feet—allowing for a reasonable margin of safety. The chamber has furthermore made it possible to reduce by fully 40 per cent the time required in decompressing a diver ascending from very deep water.

A diver, after working for a considerable while at depths not exceeding 33 feet, may return to the surface rapidly and suffer no physical disturbances; but in ascending from deeper water he must undergo one or more periods of decompression, the number depending upon the depth. Prior to the development of the Davis chamber, a diver on rising from a submergence of 204 feet, for example, where he had worked for 10 minutes, had to spend 32 minutes in climb-





Port of New York Authority Photos

SUBAQUEOUS TUNNEL DRIVING

Sand hogs are among the hardiest and most fearless of all laboring men. Their work is hazardous at the best, although many of them are physically fit after 20 or more years of service. At the top, right, is a shift waiting to pass through the manlock overhead to begin work in one of New York's subaqueous vehicular tunnels. The locks at track level are for taking materials in and muck out. The top, left picture shows a gang of tunnel drivers "locking out" in a cylinder where the air pressure is gradually reduced to normal, thereby insuring the elimination through the lungs of all the nitrogen that entered the blood stream during the period spent in "high" air. The bottom view shows the meeting of two compressed air shields driven under a river from opposite sides.

ing, by stages, the shotrope guiding him back to the surface vessel; and should his stay on the bottom last 30 minutes, then his trip upward had to take a whole hour, with pauses every 10 feet or so as he neared the surface. In cold water and strong currents, a diver might be dangerously chilled and exhausted. The submergible decompression chamber has, happily, surrounded the diver with added safeguards and assured him even some comforts during his journey to the surface.

The Davis chamber is a steel cylinder that accommodates two men—the diver and an attendant. It has a circular door at the top and a larger door at the bottom. Both open inward and each can be sealed airtight and watertight. Compressed air is delivered to the chamber from a surface vessel through a regular diving hose; and the attendant is in telephonic communication with the mother ship or diving tender. The chamber is equipped with depth gauges, oxygen administering apparatus, and steel flasks containing oxygen; and the cylinder may be suspended from a derrick and swung over the side of the tender and lowered, and when hoisted back to the surface it may be deposited on deck and secured there in an upright position.

When ready for lowering, with an attendant inside, the chamber is let down into the sea after the upper door is closed, but with the bottom door open. The chamber then functions virtually as a diving bell, and the compressed air delivered to it, which can escape through the open hatch, prevents the sea from entering, although the water may rise a few inches above the floor level. When nearing the depth at

Office of Naval Intelligence Photo

WHERE TEST DIVES ARE MADE

Interior of Experimental Diving Unit, Washington, D. C., where valuable information is obtained by simulating the conditions under which divers work. At the far end of the room is the diving tank, where the water can be placed under any desired pressure by introducing compressed air into the sealed space above it. At the left is the decompression chamber.

which the diver is to enter the chamber—that depth varying with the diver's submergence, the attendant drops a short ladder on which the diver may climb into the chamber and then seat himself upon the floor with his feet dangling below into the water. Before removing the diver's helmet and other heavy apparel, the attendant passes a safety line around the diver so that he cannot slip down through the still open hatch. When the diver's air pipe and signal line have been detached and dropped through the hatch, then the bottom door is closed. The diver is now able to stand and the chamber can be blown free of water. The fact that the chamber is filled with air at a pressure at least equal to that of the outlying water makes it easy to manipulate and to seal the hatch door.

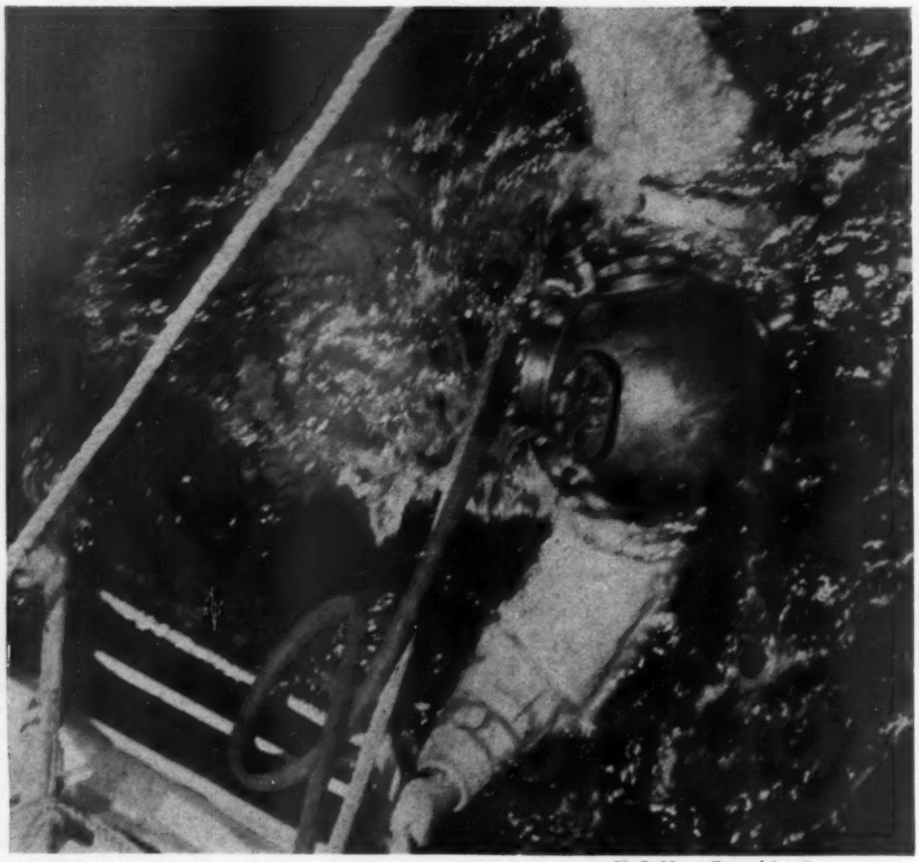
Once the chamber is sealed and hoisting starts, then the internal pressure is gradually reduced, and at definite intervals it is held constant to correspond with the periodic halts the diver would make if he were working his way surfaceward in the water. The purpose of these pauses is to permit the nitrogen taken into the body while breathing compressed air to escape again by way of the lungs as the pressure of the inhaled air drops, when atmospheric conditions are approached. Otherwise, the nitrogen, which constitutes nearly 80 per cent of the inhaled air, and which enters into solution with the blood, may be released in the blood and the deep-seated tissues in the form of bubbles that expand as the pressure on the body is decreased. Those bubbles may affect nerve centers and cause temporary or permanent paralysis, they may obstruct the circulation so as to induce symptoms ranging all the way from a mere itching through pains to asphyxiation and even death. This, in brief, is the crux of the whole problem of decompression and also the reason for the fairly general adoption of stage decompression recommended by Prof. J. S. Haldane, the eminent British physiologist.

While being hoisted to the surface in the chamber, the diver exercises his arms and legs to stimulate the more rapid dissipation of the absorbed nitrogen by way of the exhaled breath. So long as the pressure in the vessel is greater than the hydrostatic pressure corresponding to a submersion of 60 feet, the diver breathes only compressed air. From that point upward he breathes compressed air and oxygen alternately. Oxygen would be injurious if inhaled at higher pressures, but at the permissible pressures its effect is to hasten the elimination of nitrogen from the body. A few figures will make this clear.

A diver, by the new procedure, submerges to a depth of 300 feet in three minutes or less; and should this time and his stay on the bottom total 60 minutes, his decompression period will aggregate 242 minutes —slightly more than 4 hours. Within that interval, according to the new tables prepared by Siebe, Gorman & Company, he will breathe compressed air for 57 minutes and oxygen for 185 minutes—the last 60 feet taking the most time because it is the most critical period of bodily readjustment. Even so, the inhaling of oxygen will shorten by 123 minutes the time that would be required for decompression if only air were breathed.

Under some conditions, the decompression chamber can be operated as a recompression chamber, should the diver develop symptoms of distress. Instead of returning to the surface in the tedious old way, and alone in the water, the diver can now be made warm and comfortable. He is in an electrically lighted cylinder, he can be given hot coffee from a thermos bottle, and he has someone to talk to who is trained to give him every attention essential to his well-being. The chamber does not have to remain submerged while decompression is proceeding, but can instead be hoisted aboard the diving tender and that vessel may be back in port before or by the time the process is completed.

Since 1915, the Bureau of Construction and Repair and the Bureau of Medicine and Surgery, of the U. S. Navy Department, have been studying the problems associated with deep diving and the improvement of diving apparatus. Research and experimenting are still underway, and much of the work is carried on at the Experimental Diving Unit at the Navy Yard, Washing-



U. S. Navy Recruiting Bureau Photo

BREAKING WATER

A diver's head emerging from the water after a trip to the bottom. His right hand is still grasping the rope that guided him surfaceward. The return of a diver to the surface from a great depth now necessitates long exposure because of the time required for decompression. The development of the Davis chamber promises to make his ascent safer and even, in some degree, comfortable.

ton, D. C. That plant was established primarily to devise means and methods whereby divers should be able to descend to greater depths and do effective work there. This included the problem of decompression and of finding ways to shorten the unproductive period underwater. Some of the investigations have involved the use of oxygen-helium mixtures as substitutes for normal air—the inert helium taking the place of nature's 80 per cent of nitrogen. An oxygen-helium mixture has a number of advantages, but the practical adoption of such an "air" for diving work will have to wait either until helium costs much less or until a closed circuit is developed by which the exhaled oxygen-helium mixture can be recovered, purified, and reused instead of being discharged into the sea.

Helium is a third less soluble in the blood than nitrogen; and being lighter, it diffuses more rapidly than nitrogen. When breathed under pressure, less helium is absorbed in the body, and, conversely, absorbed helium can be eliminated faster than nitrogen during the process of decompression—offering still another way to shorten the period of stage decompression. The investigations have disclosed that an oxygen-helium mixture could be breathed safely at all possible diving depths. Such a mixture will not sustain combustion, while pure oxygen or air carrying an abnormal percentage of oxygen is highly inflammable. A combination of helium and oxygen, so it is reported, is superior to ordinary air for the treatment, in the recompression chamber, of any forms of caisson disease.

Despite the deliberateness of ordinary decompression, there may be circumstances that call for the faster or even immediate return of a diver to the surface, and he cannot then be decompressed by the usual underwater stages. The Navy has recently concluded a series of 2,587 experimental dives to ascertain how to guard against compressed-air illness in the circumstances just mentioned. Of course, the divers undergo recompression and progressive decompression after they are returned to the surface; and the studies have had to do with how to get the men up to the surface and then speedily into a recompression chamber before physical distress develops. Two officers of the Medical Corps of the Navy have summed up the problem in a paper prepared by them, and the essence of it is to this effect: Ordinarily in naval diving work, the men are brought up to the surface at the rate of 50 feet a minute, with stops at given depths. It has happened in emergencies that the divers have been raised directly to the surface, without stops, as quickly as practicable and then placed in a recompression chamber—the pressure there starting at one corresponding to that of the water pressure at the lowest stop called for ordinarily. The pressure in the chamber is then reduced, step by step, as usual. This procedure is now termed "surface decompression." According to the authors: "The practice of surface decompression is desirable, for it gets the diver out of the cold water and tides and into a warm chamber where he can be more easily cared for; and it releases tenders and diving gear so another diver can be sent down sooner—thus diving operations can be materially speeded up." To establish the safety of surface decompression, preliminary experiments were made at the Experimental Diving Unit.

The men donned the standard Navy diving dress, and the tests were made in a vertical cylindrical diving tank 10 feet high, 9 feet, 10 inches in diameter, and having steel walls 2 inches thick. It has been tested at an internal pressure of 400 pounds per square inch, and has six 4½-inch ports, fitted with heavy glass disks, for observation purposes. The associate recompression chamber, is a horizontal steel cylinder 14 feet, 7 inches long, 6 feet, 6½ inches in internal diameter, and with walls 2 inches thick. It is divided into two compartments by a bulkhead, in which is a door that can be closed airtight. The inner compartment is 9 feet, 8 inches long, while the outer compartment, virtually an air lock, has a length of 4 feet, 11 inches. It is thus possible to enter and to leave the inner compartment without loss of air pressure when the chamber is being used to handle divers. Each compartment has heavily glazed 3-inch ports. The recompression chamber is electrically lighted, has a loudspeaker for the telephone connection, and the internal air pressure can be regulated from either within or without. Pressure gauges are fitted both inside and outside.

In the diving tank, the men are exposed to conditions that simulate the pneumatic and hydrostatic circumstances of a submergence in sea water. The tank contains water 8 feet deep; and air pressure can be applied to the free surface of that water so as to induce a hydrostatic pressure on the divers corresponding to the pressure of any given depth of the sea—the top hatch of the tank being closed the while. In this manner, and with precision, the pressure can be increased to represent the changing pressure as a diver drops to the sea bed; that pressure can be held to correspond with the pressure on the bottom; and then it can be reduced in agreement with the time taken by the diver to ascend to his first stop and with his progress upward as he reaches and halts at his succeeding stops. In the particular series of experiments in question, the pressure was promptly restored to that of the atmosphere from the pressure at any stop from which the men were supposed to be shifted from the sea quickly to the recompression-decompression chamber.

Actual diving from a vessel followed the tank tests. The shore tests simulated dives in water varying from 100 to 167 feet; and the times "on the bottom" were as much as 90 minutes at 100 feet, 50 minutes at 150 feet, and a maximum of 42 minutes for the make-believe submergence of 167 feet. During the whole series of tests in the tank, there was only one serious case of caisson disease, and that one developed after an exposure of 42 minutes at the maximum depth. The open-sea experiments reached depths of 100, 150 and 162 feet, and the times underwater differed—being from 20 to 46 minutes during the 162-foot dives. In making their ascents, the men were required to climb only 30 feet from the bottom in order to get on a weighted stage, lowered to that depth, so as to be hoisted without further effort to the surface. On reaching the surface, they were promptly put in a decompression chamber and subjected to the required maximum pressure, before being decompressed by stages. Only three mild cases of caisson disease occurred during 112 sea dives.

The other group of tests bearing upon quick return to the surface and the possible risk of caisson disease therefrom had to do with the use of the "lung" in escaping from a sunken submarine. The "lung" is now supplied to the personnel of every submarine in the United States Navy, and consists of a light breathing apparatus, furnishing compressed or oxygen, to be worn by each individual in getting out of the foundered craft via a safety hatch. The "lung" permits its wearer to obtain sufficient air, at a suitable pressure, during the rise surfaceward through the water. The danger of caisson disease is contingent upon the time compressed air is breathed at the given depth and during the short period of ascent. One of the older U. S. submarines was used for the tests after she had been converted into an experimental vessel for training men in the use of the "lung."

Messrs. C. W. Shilling and J. A. Hawkins have thus described, in the U. S. Naval Medical Bulletin, how the "lung" was used in the experiments: "The 'lungs' are distributed individually and tested to see that they are in proper condition. The 'hatch skirt' is then placed in position under the escape hatch so that an air pocket may be maintained. (The newer type submarines have their 'hatch skirt' permanently attached). The hatch is undogged so that it will spring open when the external and internal pressures become equal. Flooding the compartment with sea water is now started and continued as rapidly as possible until the internal pressure equals the weight of water over the hatch, at which time the hatch opens and water pours in and air escapes until the level of the water in the compartment reaches the lower edge of the 'skirt'—air above the water level in the compartment thus being trapped. A buoy carrying a line is released, and, when it reaches the surface, the end of the line in the submarine is secured. The 'lung' is now charged with oxygen, the individual ducks under the edge of the 'skirt' and, grasping the line, slides slowly up through the hatch to the surface." The ascent was made usually in each case at the rate of 50 feet per minute. Before the sea tests were made, preliminary tests were carried out in the tank at the Experimental Diving Unit.

In the tank, the conditions were controlled so as to simulate depths of 100, 150, 167, 185 and 200 feet, respectively; and the time of exposure to pressure ranged, during the different tests, from maximums of 48 minutes at 100 feet and 16 minutes at 200 feet. All told, there were 2,143 "dives" in the tank; and there was a total of 361 cases of caisson disease. The officers in charge reached the conclusion that it was safe for men to be exposed for 17 minutes at a depth of 167 feet; 14 minutes at a depth of 185 feet, and 13 minutes at 200 feet. In the open sea, escapes were made by using the "lung" at depths of 100 feet and 150 feet—the exposures varying from 17 minutes to 32 minutes. There were 27 individual exposures at the different depths, with continuous ascents that averaged 1 minute in length. No symptoms of caisson disease were manifested. The dives in the open sea established that it was safe to remain for at least 32 minutes at a depth of 100 feet and for 20 minutes at a depth of 150 feet, and then to return to the surface at a rate of 50 feet per minute. The men revealed that immunity to compressed-air illness was an individual characteristic; and, during the entire series of the tests in the tank, one man made a total of 120 escapes at different depths without a single symptom of caisson disease; and eight other men made an aggregate of 666 escapes with only one attack in the case of each participant. The data developed from all the "lung" tests are being used by the American Standards Association, inspired by a number of our national engineering societies, in drawing up a code for general adoption for the regulation, in this country, of civilian workers in compressed air. That code is expected to be promulgated before the close of the present year. In this respect, The Institution of Civil Engineers (England) has set an example, having two years ago appointed a committee to draft regulations for the guidance of engineers and contractors in doing work under compressed air. The committee was composed of eminent men in the engineering, the construction, and the naval services, and included Prof. J. S. Haldane and Sir Robert H. Davis—both intimately identified with previous research work.

Heretofore, in Great Britain, there has been no code in force for compressed air workers—the responsible engineers or contractors exercising their discretion. In this country, a few states have adopted codes;

U. S. Navy Recruiting Bureau Photo

READY TO GO UNDER

A U. S. Navy diver prepares to submerge to look for a lost torpedo. The belt consists of weights to assist sinking. The attendant at the left is holding the helmet, which screws on to the diving dress.

and while all are not identical, still they are fundamentally in agreement. The aim in every case is to give the worker a full measure of protection. The code recently published in England contains the following extremely suggestive paragraphs:

"Practical experience in tunneling work has shown that the times of decompression which can safely be applied after long exposure to pressure up to about 35 pounds per square inch are definitely less than those given in the Admiralty tables, since these tables were calculated on the assumption that slowly-desaturating tissues should have a pressure corresponding to 18 pounds before the end of decompression, whereas practical experience shows that when exceptionally sensitive men have been excluded, 22 pounds is sufficient.

"Practical experience also indicates that the Admiralty times of decompression for periods of exposure up to two or three hours at pressures greater than 40 pounds are too short for caisson or tunnel work, except where very prompt and frequent use of the recompression chamber is possible. This has been clearly demonstrated in the work carried out under the direction of Mr. T. McKenzie during the raising of the warships sunk at Scapa Flow under pressures of over 50 pounds per square inch. In the Committee's opinion the reason for this is due not only to the fact that, as noted in the Admiralty Report, the times of decompression after long exposure at high pressures were shortened owing to the difficulty in keeping men for very long in the water, but also because the divers carried out vigorous exercise during decompression, thus increasing circulation and so promoting desaturation, whereas men in an air lock are inactive.

"Another consideration of the utmost practical importance in tunnel or caisson work is the fact that, after a certain period of exposure, the tissues in all parts of the body become practically saturated with gas, so that a more prolonged exposure does not give rise, with the time of decompression, to any additional risk; and as the saturation point is approached, the increased risk with duration of exposure becomes less and less. The numerous experiments carried out by the Admiralty committee indicated that after about 5 hours' exposure, the liability to symptoms does not increase. With the increased blood circulation during the work of a tunneler or a caisson worker, it may safely be assumed that the liability would increase only slightly after four hours."

The committee, therefore, concluded that the working period should be as long as other conditions permit—such as the total length of the shift, including the time of decompression, and the fitting in of successive shifts during each period of 24 hours—provided the necessary time of decompression to insure safety is given. Those experts emphasize this vital phase of the subject in this manner: "Safety has, heretofore, usually been obtained by reducing working periods to a point at which a certain limited time of decompression is required, and, in the case of high pressure, by having two working periods separated by an interval of three or four hours, thus doubling the number of decompressions per shift and causing a great waste of workmen's time, all of which has to be paid for. Actually, it is safer and more economical to employ one long working period per shift, and to meet the increased risk due to increase of pressure by augmenting as far as necessary the time of decompression. Thus, in civil engineering work, compressed-air illness should be prevented by means quite different from those usual in diving work."

In conclusion, the British committee states: "There seems no reason to doubt that work in tunnels or caissons could be carried out safely, and with reasonable economy, at pressures higher than 50 pounds per square inch." In this country, none of the codes contemplate work under pressure of more than 50 pounds per square inch; and the New York State code, for example, specifies: "No person shall be subjected to pressure exceeding 50 pounds except in emergency." While the British code contains tables for working time with either one working period or two working periods per shift, the single long period is advocated because of its time-saving without adding to the likelihood of caisson disease. The economics of the question can be easily grasped by comparison between the British code and the New York State code under corresponding conditions. Between air pressures of 18 to 26 pounds, the American sand hog is expected to work for a maximum period of 6 hours, in two 3-hour half shifts, with a minimum rest interval in the open air of one hour. Each of his two decompressions, at the maximum pressure, would take slightly more than 17 minutes. Under the British code, a sand hog working at pressures up to 25 pounds, would put in a single working period of fully eight hours with 30 minutes off for mealtime while still under pressure. His decompression would be effected within an interval of from 6 to ten minutes, and that time could be reduced one-third in the cases of experienced men. Again, let us consider the contrasting figures of the two codes when the sand hogs are under an air pressure of 50 pounds. The British code permits the men to work a continuous 4-hour shift, with a meal during the time of decompression; and the decompression period is 2 hours and 18 minutes. The Wisconsin code, adopted only 7 years ago, permits a shift made up of two 45-minute working periods, with an intervening rest in the open air of 5 hours. The minimum time allowed for each of the two incidental decompressions is 25 minutes.

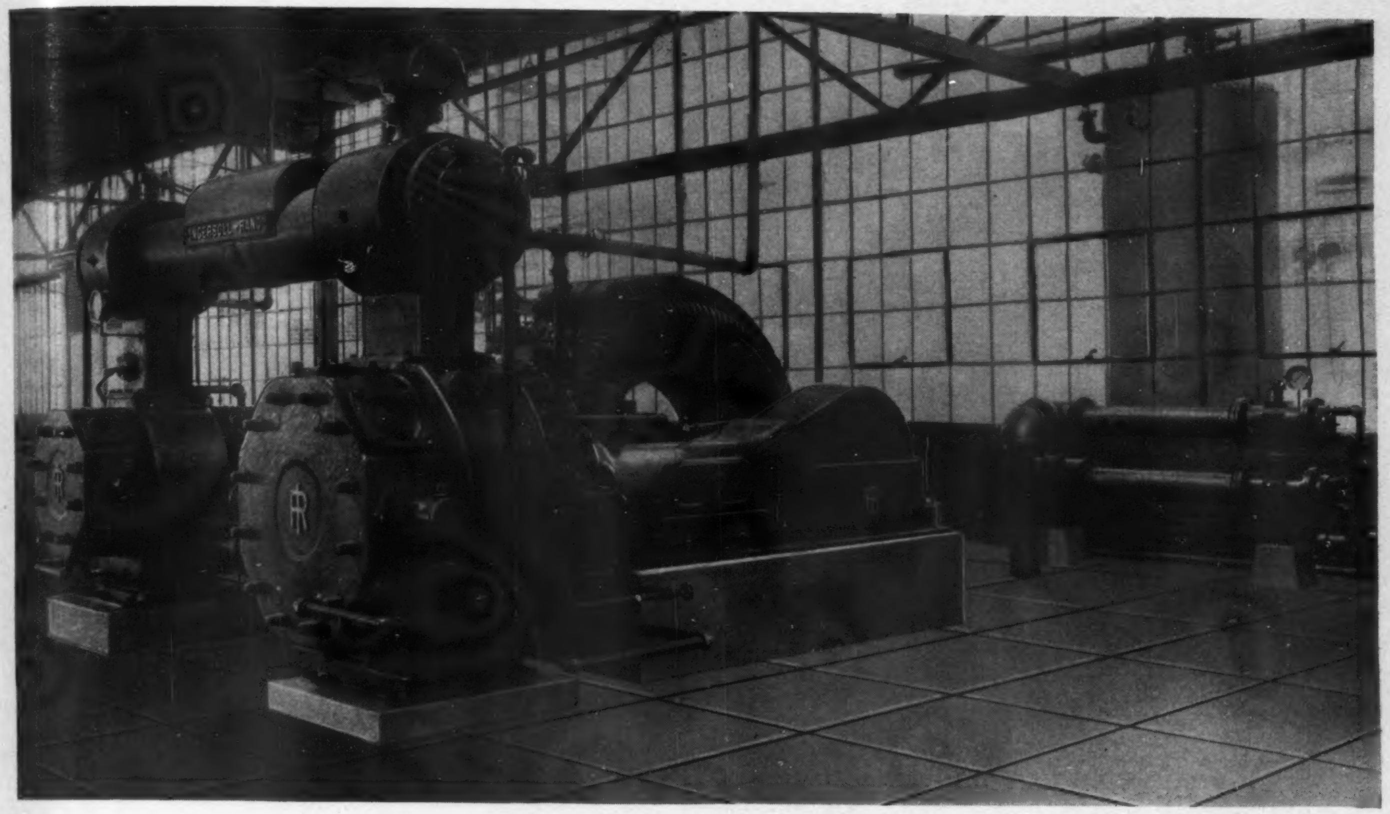
The British code contains this important note concerning the men who might be employed in tunnel-driving or caisson-sinking: "When men selected in view of previous experience in compressed air without having shown serious symptoms are employed, the Committee considers that the times for uniform decompression may at the discretion of the superintending engineer, in charge of the works, be progressively reduced to two-thirds. The effect of each reduction on the incidence of cases should be carefully noted and successive reductions regulated accordingly. The number of cases requiring recompression in any one week should not be allowed to exceed 2 per cent of the number of decompressions."

While in selecting men for work under compressed air preference is given to those of athletic build and under 40 years of age, certain British engineering-contractors of ripe experience believe that such a limit is not necessary, provided the heart and lungs of a man are found in good condition and he is not hampered by an excess of fatty tissues. This is based upon the fact that many divers are more than 38 years old; and many lean, healthy men of 50 years and more are working continually under high air pressure. It is because of these variations that the engineer in charge is given discretionary power in regulating the conditions under which qualified and physically fit pressure workers can be employed.

The present knowledge of conditions affecting pressure workers is the consequence of much research with which the general public is unfamiliar; and even though these investigations have shown how the diver and the sand hog can go ahead in confidence where they previously needed to hesitate, still their working range may be still further extended by additional study. Certain it is that the human body has astonishing adaptability, and because of it the pressure worker is going to help the engineer put through a great many huge undertakings in coming years in circumstances where Nature has always previously seemed to call a halt.

THE CAUSE OF "BENDS"

A microphotograph of a section of the spinal cord of a goat that died as the result of too sudden decompression after an exposure to high air pressure. The arrows point to bubbles of nitrogen that caused paralysis and death.



A GOOD COMPRESSOR PLANT LAYOUT

This installation is in an Indiana factory. At the right is an HM-2 aftercooler and beyond it, showing through the window, is the outdoor receiver. All intake and discharge air piping has been run beneath the floor. Ample room has been provided for doing any necessary repair work on the compressor, the room is well lighted, and the floor is clean.

Safety in the Compressor Plant*

Charles W. Gibbs

COMPRESSED air is probably "handled" by more workmen in the average plant than either steam or electricity. Because of this widespread usage that extends even to small operations (practically every automobile filling station has a compressor), the consideration of safety in the installation and operation of compressed air systems is important. This discussion will be limited to the equipment that compresses and distributes air and will not touch upon the tools and machines in which the air is used. Neither will it cover the compression of gases other than air, such as natural or manufactured illuminating gas or the many special gases used in process or refrigeration work.

By way of approaching the subject in a somewhat orderly manner, the selection of the compressor and auxiliaries will be taken up first, their installation next, and their operation and maintenance in conclusion.

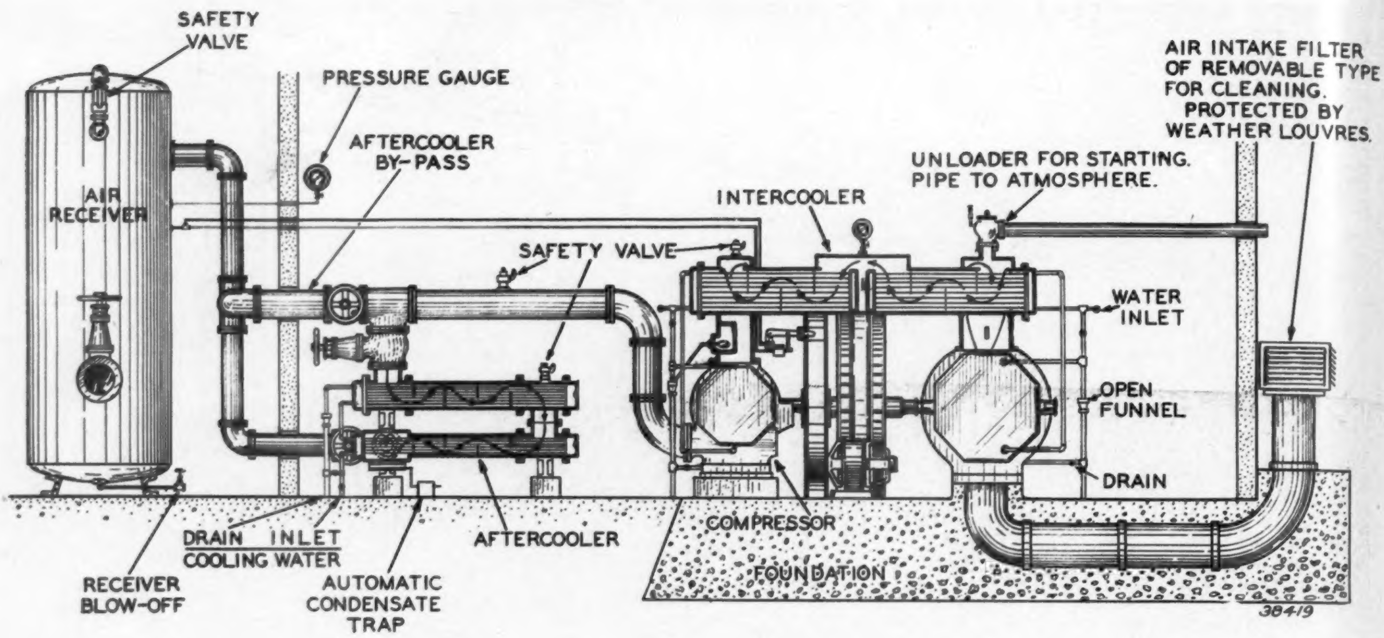
It goes without saying that all equipment should be designed to withstand the maximum pressure that *might* be encountered in the particular application where it is to be used. Note the emphasis on "might." No difficulties need be met in this regard, as all reputable manufacturers of compressed air equipment are prepared to offer units that will provide an ample factor of safety over and above the normal pressure range for any given service.

In the average industrial plant, the operating pressure will seldom exceed 150 pounds. This can be provided by either a single-stage or two-stage compressor. In general, machines of more than 100 horsepower are two-stage, as the power requirement for units operating at 100 pounds discharge pressure is about 15 per cent less than for single-stage design. A two-stage compressor provides greater safety than a single-stage machine for the reason that the discharge temperature is lower. The effect of this temperature will be discussed in more detail later.

Particular attention should be paid to the method of regulating the compressor output to prevent the building up of an excessive pressure in the system. All compressors are or should be provided with some means of varying the volume of air compressed and delivered to the system so that the output is averaged up to that which is being taken from the system. A steam-driven compressor may be regulated by automatically varying the speed in accordance with the demand, thus maintaining an approximately constant discharge pressure. Electric-driven compressors operate of necessity at constant speed.

There are several methods of regulating constant-speed compressors, and the choice usually depends upon the size of the unit.

*Condensed from a paper, "What the Safety Man Should Know About Compressed Air Systems," delivered October 13 at the National Safety Congress in Kansas City, Mo.



RECOMMENDED COMPRESSOR PLANT LAYOUT

To insure maximum coolness, air is taken in from outdoors. It is filtered to remove dirt that would not only increase wear on the compressor, but also might build up oil-laden deposits that would constitute a fire hazard in case a broken valve permitted the discharge temperature to rise unduly. Discharge air passes directly to an aftercooler, where moisture and oil are condensed and removed, and then to a receiver. The latter is located outdoors to gain the advantage of radiation to atmosphere of any heat remaining in the air. Note that a safety valve is installed on the discharge line from the compressor.

Small machines, such as those used in automobile service stations and garages and in certain applications in industrial plants, are most frequently equipped with automatic stop-and-start control. They operate at full speed until the pressure in the system reaches a predetermined point, when a pressure switch opens the electrical circuit and stops the motor and compressor. When the pressure drops to some lower predetermined figure, the switch closes the motor circuit and the compressor resumes operation. Where automatic stop-and-start control is not advisable, a so-called constant-speed control is provided. The compressor operates at full speed at all times, the output being reduced in one or more steps to zero, maintaining the discharge pressure below a predetermined maximum. On small and intermediate size units, constant-speed control is generally "all on—all off." That is, the compressor either delivers its full output or none at all. Some compressors use what is known as free-air unloading, in which the inlet valves are held open, preventing the compression of air during the unloaded period. Another system requires a high-pressure relief valve to exhaust the air in the high-pressure cylinder to atmosphere, while the intake to the low-pressure cylinder is closed off entirely, thus preventing the further compression of air.

On larger constant-speed units, a system of step control is used, the most satisfactory of which is the automatic clearance control. This operates on the principle that less air will be delivered by a compressor if the clearance space in the cylinder is increased. By opening a suitable number of valves connecting clearance pockets to the cylinder, any desired degree of unloading may be obtained. Free-air unloaders of various types are also used on large units, but they are not so satisfactory, mechanically, as the clearance control.

Small steam-driven compressors usually have a throttling (flyball) governor or some form of automatic cut-off governor. These act as maximum speed control devices only. Control of output is by one of the constant-speed methods previously described. Larger steam-driven units may be equipped for varying the speed to maintain a constant pressure with a built-in device limiting the maximum speed. In addition, it is wise to have an automatic safety device which acts to shut off all the steam if the safe speed is exceeded.

The important thing about the compressor and its regulation or control, from the safety man's standpoint, is that the control should be reliable and as fool proof as is consistent with the requirements.

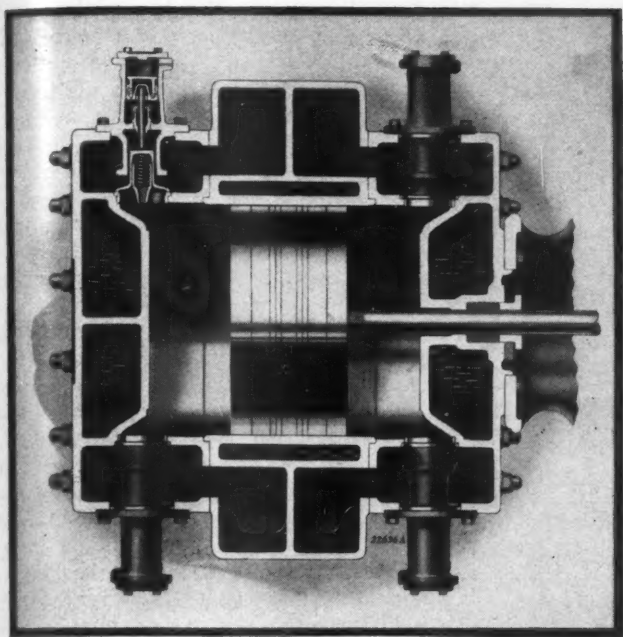
Intake air should be filtered to keep most of the dust and dirt out of the compressor. This reduces wear and valve leakage, and, in general, makes for a better, safer, longer-lived and more economical unit.

The wise purchaser will also install an aftercooler to cool the air as it comes from the compressor and before it passes into the air receiver and thence into the distribution system. The aftercooler condenses any excess oil that may be carried through the machine, and condenses the water vapor that is always present to a greater or lesser extent in the intake air and which is squeezed out when the air is compressed, much as we squeeze water out of a sponge. It also eliminates the weakening of pipe lines by alternate expansion and contraction as a result of heating and cooling. The aftercooler should be designed with ample cooling surface and be built to withstand the pressures encountered. It should be protected with a safety valve and should have a pressure gauge to indicate at all times the pressure existing within it. Aftercooling will be discussed in greater detail later.

Every air compressor plant should have one or more air receivers. These are simple tanks designed to assist in the removal of moisture and oil before the air passes into the distribution system, to provide a reservoir against the peaks of usage, and to maintain a more constant pressure in the system. The compressed air industry has practically standardized on the manufacture of receivers and auxiliary equipment that meet the A.S.M.E. Code for Unfired Pressure Vessels. Each receiver should be designed for a pressure slightly higher than the normal expected operating pressure and should bear a stamp of inspection showing that it meets the code. This simplifies insurance problems.

The use of air receivers or tanks which have not been regularly inspected and tested is still too prevalent and cannot be too strongly condemned. It is the fixed policy of our company* not to quote on air receivers built for pressures of less than 125 pounds. We feel that if we were to sell receivers, for say 30 pounds or 50 pounds pressure, even though they were built to the A.S.M.E. code, they might sometime, somehow, be used for higher pressures with disastrous results. One

*Ingersoll-Rand Company

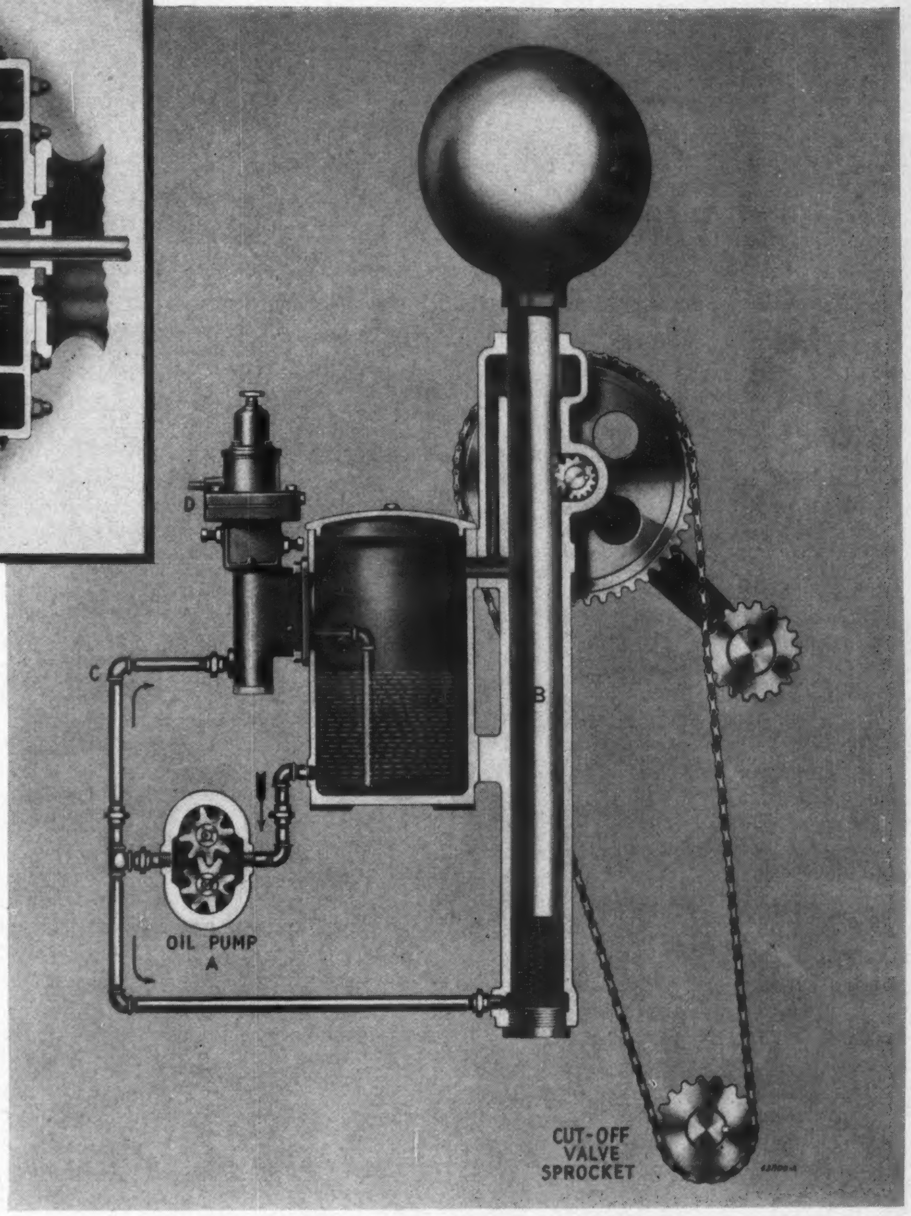


hundred pounds is the practical standard of air pressure in this country and a receiver designed for 125 pounds provides a sufficient safety leeway.

It hardly seems necessary to state that valves and fittings should be designed for the pressures involved and should be carefully selected and installed. These parts have now been well standardized and can be bought with safety.

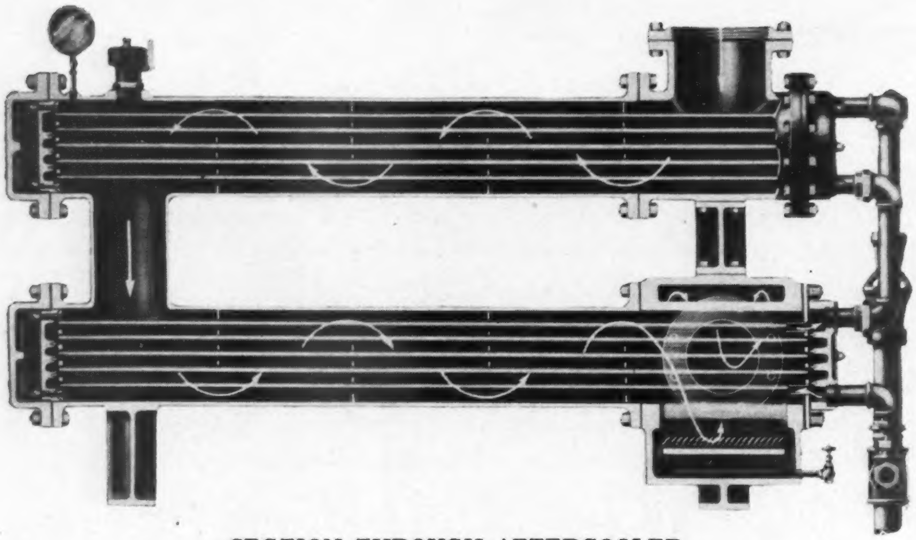
We now come to a consideration of installing the compressed air plant properly. First, of course, a suitable location must be selected. From the viewpoint of safety as well as of economy, the space should be well lighted, have crane service if necessary for handling heavy parts during erection, maintenance, and repair; and should provide plenty of aisle space.

Piping should be arranged so as to be out of the way and yet accessible. Intake air should be brought in from the outside if at all possible, since the colder it is when it reaches the compressor, the less will be the likelihood of excessive discharge temperatures and the greater will be the useful capacity of the unit. The air filter should be placed where it can be well and conveniently serviced, and should be regularly cleaned. Discharge piping is important. The air coming from a compressor is hot: at 100 pounds pressure its temperature will vary from 250°F. to 400°F., depending upon whether the machine is two-stage or single-stage and also upon the volume of cooling water used and the effectiveness of the cooling system. Because of this temperature, the discharge pipes should be where men cannot easily come in contact with them. They should be carried upward and out of the way, or laid in pits beneath the floor. They should lead as directly as possible to the aftercooler and the shorter the distance between the compressor, the aftercooler, and the receiver, the greater will be the over-all operating economy of the in-



TWO TYPES OF REGULATORS

It is essential to the safety of an air compressor that it be equipped with some effective and reliable means for regulating the output so that the sytem will not be subjected to a higher pressure than it was designed for. On steam-driven machines regulation is accomplished by governing the speed of the engine. The illustration directly above shows the governing mechanism that is used on larger sizes of modern Type XPV compressors. The volume of steam admitted to the power cylinders, and consequently the speed of the engine, is controlled by the cut-off-valve sprocket. This, in turn, is actuated by up and down movements of the rack and weight *B*. These movements depend upon the pressure of oil underneath the plunger. The oil pump *A* is driven by a chain from the main compressor shaft. Accordingly, any change in the speed of the machine is instantly reflected in an increase or decrease of the oil pressure under the plunger and this serves to increase or decrease the volume of steam and thereby to bring the machine to the required speed to maintain the desired pressure. Variations in the demand for air also affect this oil pressure by means of a diaphragm-operated valve *D*, which by-passes a portion of the oil through the pipe *C*. Electric-driven compressors operate at constant speed, and various methods of regulating them are employed. One of the most successful of these is the automatic clearance control that was patented by Ingersoll-Rand Company some 20 years ago and that is still used on larger machines made by that concern. The view at the left shows a section through a compressor cylinder equipped with two clearance pockets at either end, each of which has its control valve. When one valve opens, the volume of air taken in at that end of the cylinder on each suction stroke is cut in half. On the compression stroke, the entrapped air goes into the clearance pocket and on the suction stroke it expands and helps move the piston towards the other end of the cylinder. Thus, with one clearance pocket open, the output of the machine is three-fourths of its capacity. As there are four pockets, the output can be regulated in five steps, namely: full capacity, $\frac{3}{4}$, $\frac{1}{2}$, $\frac{1}{4}$, or zero. This is accomplished automatically, in accordance with the demand for air.



SECTION THROUGH AFTERCOOLER

An aftercooler pays dividends in several ways. It is perhaps the best safety insurance that can be obtained in a compressor plant. It eliminates high temperatures in the distribution system, thereby nullifying the danger from fire and reducing pipe line troubles. It also removes the need of blowing out pipe lines to expel accumulated moisture and consequently contributes to the prevention of accidents. Shown here is a section through an HM-2 aftercooler. Air enters at the upper right, is directed by baffles back and forth across the nest of tubes containing cold water, and then flows to the lower shell, where the process is repeated. It leaves the cooler at the bottom right, where a separator and automatic trap remove condensed moisture and oil. Water enters at the lower right, flows back and forth through successively higher banks of tubes and then to the upper tube nest, where the same procedure takes place. This counter flow of water and air makes for the highest cooling efficiency with the lowest consumption of water.

stallation. No valves should be placed in the line between the compressor and the receiver. This statement is made despite the fact that valves frequently *are* placed in the line, and notwithstanding the fact that there are cases where the space is so limited as to require that two or more machines discharge into the same receiver and valves must accordingly be placed in the discharge lines at the compressors. Where this cannot be avoided, it is absolutely essential that a safety valve,—at least as large as that on the receiver—be installed between the compressor and the shut-off valve. But again it should be emphasized that no valve *should* be put between the compressor and the receiver. Other arrangements *should* be made if possible. It has been suggested that the best safety sermon on compressed air would consist of the words, "Don't put a valve between the compressor and the receiver!" repeated 500 times. Safety is flouted daily because that command is disregarded.

Both the aftercooler and the receiver should be arranged to drain effectively, so that there will be no danger of freezing water in the winter time, and so that all moisture will be trapped and removed from the system as fast as it is condensed. Placing the receiver outdoors promotes maximum cooling of the air by radiation to atmosphere, and conserves valuable floor space. In most climates the aftercooler should be indoors to prevent freezing.

Receivers usually have one opening near the top and one near the bottom. There is great controversy as to whether the inlet should be at the top, and the outlet at the bottom, or vice versa. A better piping layout, with less interference with passageways, etc., is possible when the inlet is at the top, but otherwise it probably doesn't make much difference.

All water piping should be laid out so that it will drain thoroughly and that it will drain the compressor cylinders and aftercoolers as well. This must be watched particularly in the winter time, if there is any possibility of temperatures in the building dropping to the freezing point. It is easy for a cylinder head to be cracked by freezing and possibly weakened enough to make the machine dangerous to operate.

A well planned system for distributing the compressed air to the various points of consumption will take into consideration the slope of the lines and the location of drop legs and drains. There should be no low pockets which are not regularly and frequently drained. The installation of automatic moisture traps is recommended.

During certain parts of the year when the water used for aftercooling is relatively warm, small quantities of moisture and oil may be carried into the pipe lines and condense there. The moisture tends to collect toward the ends of the lines, causing trouble at points where the air is used. It is necessary, therefore, that this condensate be removed from the system. In many shops this is accomplished by opening a line and allowing it to blow for a considerable time before putting the air to use. This is neither a safe nor a wise practice, and the need for doing it can be removed by laying out the distribution system with care.

After it has been installed, the equipment should be painted and afterward kept clean at all times. This applies also to the windows in the compressor room and to the walls and floor. Every safety man knows the advantages of clean and attractive surroundings and well-kept machinery.

We now come to the operation of the plant. Having selected the proper equipment and having installed it in the proper way, the owner must see that in its everyday use nothing is permitted to happen that would create hazardous conditions. The compressor must, of course, be driven by some prime mover. It is assumed that suitable protective devices have been installed on this prime mover and that it is installed in such a way that there will be no danger of overspeeding. Reference to various safety codes should bring out the necessary safeguards for each individual case.

On the compressor end, it should be made certain that the regulators or controls are in proper operating condition at all times. There should be no valves of any kind in the piping between the pressure regulators themselves and the vessel in which the pressure is being maintained. If there *is* a valve in this line, it should be a routine part of every daily inspection—particularly before starting the compressor—to see that this valve is open and the line is clear. The valve should be installed so that the pressure is *under* the seat, thereby insuring that it cannot be closed by air pressure if the valve stem should break. Here, again, is a valve that should not be in the system, but frequently is.

It is a very simple matter to test most regulators manually, either before the machine is started or immediately thereafter, and this should be a routine part of the operator's procedure. Most air compressors unload frequently enough to keep the regulators in working condition, but there are cases where they are used as base-load machines and eventually the regulators become stuck and will not function when necessity arises.

Steam-driven units should be frequently checked to see that the governor does not permit safe maximum speed to be exceeded. Automatic safety stops should be tripped at least once a week and preferably more often. These precautions are often grossly neglected. Running "on the throttle" should be prohibited.

Cooling water for cylinder jackets and aftercoolers is very important. Its source of supply should be reliable, and it should be as cool as can readily be obtained. Most water-cooled compressors have a control valve on the water inlet and an open funnel arrangement at the discharge to permit visual checking of the amount of water flowing. The exact temperature of the water at the outlet is not of great importance, but it should not exceed certain limits, even where water is expensive. A good general rule is to keep it below 120°F.

Cooling water must be clean. If it contains scale-forming substances, channels

of flow will eventually become restricted, heat removal efficiency will be lowered, and the result will be higher discharge air temperatures, which is always a potential source of danger and trouble.

Lubrication of an air compressor has more to do with safety than any other one thing. An air compressor requires extremely little oil, but the oil should be of the best grade from a reputable firm, and selected specifically for compressor service. When first starting a new compressor, it is wise and customary to feed oil generously. This helps to give the cylinders a fine polish and assists in washing out the dirt which is found in any new machine, no matter how carefully it has been cleaned out before starting. After a few days of running with a generous amount of oil, however, the supply should be cut down until the intake and discharge valves become only slightly greasy, not dry, and not oily. There should by no means be oil lying in the valve pockets or in the cylinder discharge passageways.

Compressor valves are subjected to extremely hard service. They open and close very rapidly and are consequently made as light as is consistent with their required strength. It is not to be expected that valves will last indefinitely, and they must be occasionally replaced. Valves should be regularly inspected—the period between inspections being dependent upon the particular service the machine encounters, plus experience. Valves should generally be removed every three to four months, cleaned, and thoroughly examined for broken or excessively worn parts.

When a broken valve—and particularly a discharge valve—is allowed to operate for any length of time, the leakage of compressed air back into the cylinder during the suction stroke increases the compressor discharge temperature severely. Valves are likely to break if dirt is permitted to accumulate in the system. This dirt is liable to be oil soaked if an excessive amount or poor grade of oil has been used, and will soon become baked into a hard, carbonaceous mass. Eventually the temperature may rise so high that this deposit will start to burn. Combustion will be rapid in the dense atmosphere of oxygen. This is, of course, a very dangerous situation because if there is enough of the oil the pipe or vessel may become red hot and unable to resist pressure. Then an explosion occurs. When this happens, the piping or vessel is fortunately not always ruptured. But there is always danger that it willbe.

The use of air filters on the compressor intake is not only an economically sound procedure from the standpoint of reduced maintenance and longer life on the compressor and valves, but also from the standpoint of safety because clean valves are less likely to leak and cause excessive temperatures, and if they do leak for a while before they are discovered there is less chance of there being a carbonaceous deposit present to catch fire. Air filters should be cleaned as frequently as may be necessary. The frequency will, of course, depend upon the location and the running time of the compressor. They should be inspected not less than once in every six weeks, and preferably more often.

The air receiver requires little attention other than occasional painting of the outside and inspection of the inside to make sure that corrosion is not taking place. Normally, the insides of pipe lines and receivers become covered with a very thin coating of oil which protects them to a certain extent. Safety valves should be checked to see that they are functioning and are set at the proper pressure to protect the system. On an A.S.M.E. receiver, the safety valves should not be set above the pressure for which the vessel was designed and which is stamped on it. All safety valves should be sprung by hand at least once a day to insure that they are in good operating condition and to clear them of any dirt that might lodge in them. The safety valves themselves should be designed and stamped to meet the A.S.M.E code requirements, and should be connected directly to the receiver with no intervening valve and as little piping as possible.

An aftercooler will do more to reduce whatever hazards may exist in the operation of an air compressor than any other single piece of equipment. It does this by eliminating high temperatures in the receiver and distribution system and by preventing the passage of excessive quantities of oil. The result is positive insurance against explosion or fire in the system. Many plants feel that an aftercooler is a worthwhile investment from this standpoint alone. An additional gain is the elimination of condensed water at the system outlets, which renders it unnecessary to blow out the lines, and materially reduces the upkeep of air-operated tools.

The question frequently is asked, "How far should the air be cooled in an aftercooler to accomplish the desired results?" The answer is, as usual, a compromise between the cost and the results obtained. The compressed air industry has standardized on cooling within 15° F. of the incoming water temperature. This keeps the coolers economical in size, requires a minimum amount of water, and reduces the temperature of the air to a point where most of the moisture is condensed and may be removed. The explosion hazard is entirely eliminated.

The most important air compressor safety precautions may be summarized as follows:

- Buy all equipment, particularly receivers, safely to meet the pressures involved.
- Install properly with as few valves in the system as possible and *none* between the compressor and receiver.
- See that operators check the regulators and governors manually every day.
- Inspect and clean all compressor valves at least every three months.
- Operate safety valves manually every day.
- Check the quantity and quality of oil used in the compressor cylinders.

AIR FILTERS AND RECEIVER

The exterior of a well-designed compressor plant at the Hinderliter Tool Company in Tulsa, Okla. The air intakes are well above the ground level, where less dust is in the atmosphere, and are protected by filters. The receiver is of large size and is located outside the building, which insures cooler and drier air during most of the year.

Scraper Loading Aids Joplin Mines

C. W. Nicolson*

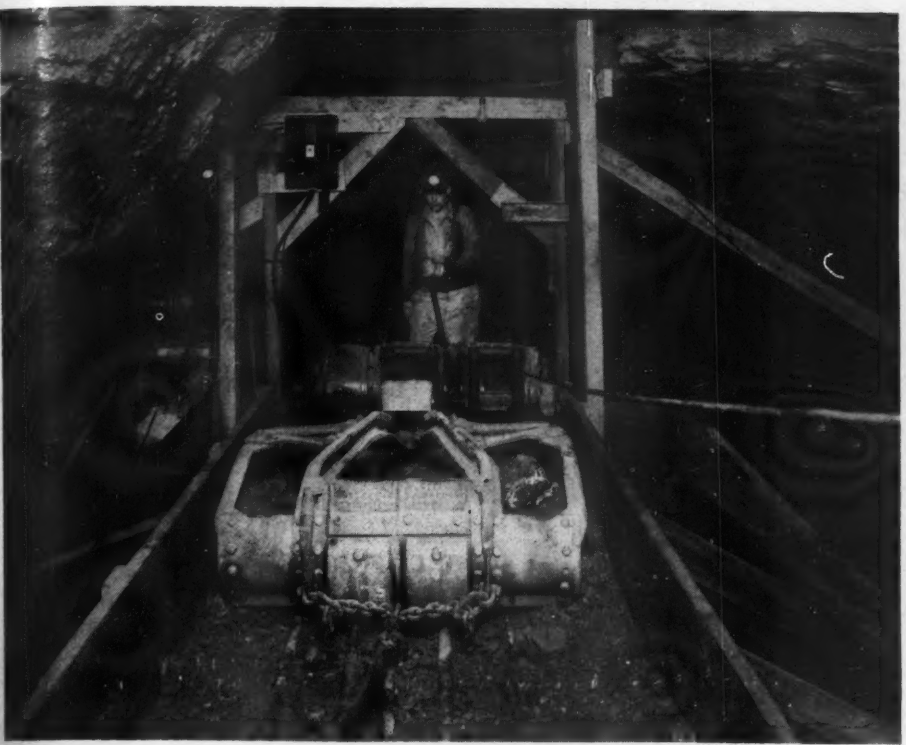
SLUSHING IN A LARGE STOPE

The scraper at the right is hauling ore up a 30 per cent slope for loading cans beneath the platform at the top of the picture. It is powered by an Ingersoll-Rand 3-drum electric hoist. The center drum operates the pull-in cable, and each of the side drums operates a pull-back cable. These latter cables may be seen extending from the hoist platform to either side. They pass over sheaves located outside the field of the camera and return, at a lower level, to the scraper, where they are attached. This arrangement enables the operator to maneuver the scraper to any portion of the muck pile and, consequently, to load all the broken ore from the one set-up. Above is a side view of the loading platform, showing the hoist and the scraper at the top of the incline, where it has just dumped its load into the ore can on the railroad car beneath it. Cars bearing the cans are spotted by a cable operated by a smaller hoist. The pictures were taken in the Black Eagle mine of the Eagle-Picher Mining & Smelting Company.

One of the recent developments in the mining practice of the Tri-State District (parts of Missouri, Kansas, and Oklahoma) has been the introduction of the scraper method of loading ore in place of the heretofore prevalent system of hand shoveling. As a matter of fact, while we speak of this system as being new to this district, it was really first tried here some twenty years ago, even before it was tried in other parts of the country. At that time, however, this method did not meet with the approval of the local operators for several reasons. One was the lack of small, compact hoists for this service, another the faulty design of the scrapers themselves and a third, the local prejudice in favor of hand shoveling which was considered to be a more flexible method. The system was adopted, however, in other parts of the country, notably in the iron ore district near Lake Superior and as a result of the experience in those districts much more satisfactory equipment has been designed and placed on the market by several manufacturers.

Briefly the system consists of the use of a scraper or "drag" which is moved back and forth by steel cables. The hoist to which these cables are attached has either two or three drums and is actuated by either an electric motor or an air-driven motor. From the front of the scraper, one rope leads directly to the hoist by which the loaded scraper is pulled forward to the dumping point. From the back of the scraper another rope goes back to a sheave block which is attached to the wall at the working place and thence back to another drum on the hoist. By means of this cable the

*General Superintendent, Eagle-Picher Mining & Smelting Company.



A 2-DRUM HOIST

An installation at the top of a permanent slide in the Big John mine of the Eagle-Picher Mining & Smelting Company, showing details of the hoist and scraper. The hoist is an Ingersoll-Rand 25-hp., 2-drum unit. One drum operates the pull-in rope and the other the pull-back rope. At the left is a smaller D6U "Utility" hoist that is used in switching ore cars beneath the loading platform.

empty scraper is drawn back to the loading point.

The principle is exactly the same as is used by the loading drags at the tailing mills of the district, the fundamental difference being the compact design of the hoist and the design of the scraper itself. While the large double-drum hoists used at the tailing mills could be used for underground service, they are far too large and heavy to be readily moved through the mine. The hoists as developed for underground service are about five feet long, two feet high, weigh from 2,000 pounds to 3,300 pounds complete, and are powered with 15-hp. or 25-hp motors, or for lighter service, with air-driven motors developing about 13 horsepower.

The plate-type of drag as used on the tailing piles will not handle broken ore underground as it contains a large proportion of chunks or boulders. The scrapers now being introduced for underground service are from 42 inches to 48 inches wide and about 60 inches long and are made with curved back plates and short side plates, forming a sort of a box. They are so designed that as the scrapers pull forward they sink into the pile of broken rock until fully loaded, after which they cease to dig and will ride over the irregular surface of the pile. This prevents the scraper from pushing broken rock in front of it and thereby overloading the hoist, and the side plates keep the scraper from losing its load. In order to withstand the severe usage underground the scrapers are heavy, weighing from 1,200 to 1,500 pounds, are made of cast steel and use chrome-molybdenum steel at the points of greatest abrasion.

In practice the hoists are mounted on elevated platforms built either of wood or steel, depending upon the permanency of the installation. The scraper is pulled up a long sloping approach or ramp on to this platform and the broken rock then falls through a hole in the platform into cars or cans which are used to convey it to the shaft. The scraper most commonly used in the district is 48 inches wide and is operated with a 25-hp. hoist, with which equipment it is possible to drag about 1,500 pounds of rock with each trip of the scraper, this being about the capacity of a 32x32-inch can. The cans are usually handled in trips of six and are pulled under the platform by a small air-operated "Tugger" hoist. After being loaded one at a time, the trip of six cars is pushed back on to the lay-by, or siding, and another trip of empties pulled forward. The usual crew for such an operation consists of the hoist operator and a helper who spots the cans under the platform, breaks boulders too large to go into the cans, moves the sheave block to new positions and assists in such other ways as may be necessary. These scrapers can pull rock in from a distance of 250 feet, but 200 feet is usually considered to be an economic limit, after which it is better to move the platform forward. Under favorable conditions it is possible to load, in this manner, 400 cans per shift.

Where the mine is being operated on an upper level so that it is possible to scrape the broken rock to a hopper or to a raise, the daily capacity can be considerably increased. Working under such conditions with a large pile of broken rock to be handled, a scraper can easily move 600 cans per shift.

In mines where the headings are wide, such as sheet ground mines, the present tendency is to use hoists having three drums, the center drum being used for the pull-in rope and the other drums each having a pull-back rope which passes over sheaves set on either side of the wide heading and thence to the back end of the scraper. By means of these two ropes the scraper can be maneuvered to any part in the wide drift and can clean up all the broken rock without leaving any ridges or trenches.

In mines where it has been found that sufficient rock cannot be broken in one drift each day to keep the scraper busy, or where it is desired to place the hoist so close to the working face that it would be injured by blasting if left in place, a recent development has been the use of a portable steel ramp on wheels, the hoist being mounted above the ramp. By this method the entire outfit can readily be moved from one drift to another or it can be pulled back at night out of the way of the blasting.

The scraper system of loading is particularly applicable to the sheet ground mines or to other mines in which the ore is of such low grade that the cost of hand shoveling is prohibitive. By use of scraping equipment it is possible to operate some of these low-grade mines at a profit, thereby employing a larger number of men. While it is true that this method requires fewer men in any particular mine than would be required by the older methods, it offers possibilities of greatly increasing the life of the Tri-State district, since it is known that there are available in the district large tonnages of low-grade ore.

While this system has not been universally adopted as yet in this district, the experience in other parts of the country indicates that it should continue to increase in favor and that the productive life of this mining district should be materially prolonged.

AMONG the new processes that have been introduced in the mining industry in recent years, none has contributed more to economical and profitable operation than scraping or "slushing." As the author of this article points out, the reduction in the cost of loading ore that scraping makes possible enables mine owners to work ore bodies of lower grades than in the past. This, in turn, creates more employment.

OIL FROM COAL

FIFTEEN or twenty years ago, when it appeared that our petroleum reserves were in imminent danger of being exhausted, much was heard about the possibility of obtaining crude oil from carbonaceous shales. The major oil companies hastened to secure control of some of the billions of tons of this oil-bearing rock that was lying undeveloped in Colorado and Utah; and even the leaner deposits of Kentucky were not overlooked.

Pilot plants were set up to experiment with processes of extracting the oil from the rock. The Bureau of Mines lent a helping hand, and research was carried on at the University of Colorado. There was feverish activity for a year or two, and the more enthusiastic among the shale promoters envisioned a mammoth new industry.

But science dissipated those roseate dreams and decreed that we were to go right on, for some years to come, taking petroleum from the ground in the conventional manner. The scientific wand that was waved at that time was geophysics. It enables geologists figuratively to look into the ground and trace out structures favorable to the accumulation of petroleum. Concurrently with this advance, practical oil production men developed machinery and methods for drilling wells deeper by far than they had ever before penetrated.

Then science stepped into the situation again, this time with the hydrogenation process. German technologists showed more than ten years ago that by combining heat, pressure, hydrogen, and coal, the latter could be made to yield oil. This discovery had more significance abroad than here, because petroleum deposits are fewer there and gasoline prices are higher. Nevertheless, American scientists began a systematic program of development of the new process and it has produced some very encouraging results. Last month it was reported to the American Chemical Society that Dr. H. H. Storch and his colleagues in the Bureau of Mines had succeeded in converting 84 per cent of Pennsylvania coal into a liquid similar to petroleum, and which can be refined into approximately equal quantities of light and heavy oils. So far they have worked with only 100-pound lots of coal, but there is no reason to doubt that the same method will prove successful on a large quantity basis.

TRENDS IN ADVERTISING

GOVERNMENT figures disclose that American manufacturers will spend some $70,000,000 this year for advertising their products through chain radio programs. Large though it is, this sum represents only what they will pay for use of the broadcasting facilities—the cost of talent is not included.

Certain articles can be sold over the air; others cannot. Makers of drugs, toiletries, and soaps will pay one quarter of the 1937 radio advertising bill. Food manufacturers will pay another quarter, automobile makers approximately one-sixth, and the remainder will be divided among manufacturers of miscellaneous articles. The value of radio as an advertising medium for any product is directly proportional to the number of people that are potential users of that product. Anything that we all use can be sold by radio; anything that only a few persons in each community require demands a more selective advertising medium.

Industrial machinery falls in the latter classification. The trade journal has always offered the most effective means of advertising such products to the trade and its position remains unchallenged, despite the changing trends in the field of general advertising. There are more than 1,200 trade journals published in the United States. Each specializes in a particular field and, accordingly, interests a specific group of readers. By using these publications, industrial advertisers may concentrate their sales fire directly upon the desks of those they desire to reach. Selling an air compressor or a rock drill by radio would be a stroke of luck.

POWER GENERATING COSTS

THE RECENT survey of the National Resources Committee, a Governmental agency, contains some interesting information regarding the relative costs of generating electric power by steam and by water. In effect, it points out that under average conditions, steam generation will prove the less expensive of the two. This is primarily because, save where natural conditions are unusually favorable, steam plants must be provided as reserves for hydroelectric installations, thereby running up the cost of the investment. Making allowance for such reserves, hydroelectric plants will ordinarily cost in excess of $150 per kilowatt capacity, as compared with $75 to $125 for steam plants.

Under average conditions, a steam plant will deliver current at the power house bus bars for 4 mills per kilowatt hour, as against 6.3 mills for a hydroelectric plant. These figures include fixed charges and operating expenses and are based on installation costs of $85 per kilowatt capacity for steam plants and $250 for hydroelectric plants.

Declaring that the high efficiency and low fixed charges now possible in large fuel-burning plants place hydroelectric developments at a disadvantage in most sections of the United States if low power cost is the objective, the report points out that in most regions in this country the hydroelectric plant should be considered as complementary to the steam plant rather than as the main source of power.

"There is need," the committee reports, "for accurate studies to develop the proper proportion of hydro to steam plants in different sections of the country for the most economical power generation. Hydroelectric plants are practical where good water sites are available, not too far from load centers, with well sustained continuous water flow, or with water storage which can be developed at low cost. But, present low costs of steam plants necessitate discrimination in developing water power sites."

Montana Miners Compete at Drilling

THE TRADITIONAL feature contest of holiday celebrations in American mining camps in years gone was always a hand-drilling competition. Such events are still popular, but the air-driven rock drill has to such a great extent supplanted hand work in the mines that it is also gradually replacing manual methods in the contests. This perhaps deprives them of some of their color, but they are still spirited affairs. And, contrary to what the layman might suppose, the human equation still enters largely into determining the winner. Even when using the same rock drill, there will be a wide variation in results obtained by different men.

This was well demonstrated in a contest staged at Phillipsburg, Mont., last Labor Day by Miners Union No. 24. This was a competition between two-man teams using drifter-type drills of 3½-inch cylinder bore. Three manufacturers of drills coöperated with the miners by furnishing them with a new drill of their make. The rules provided for mounting the drill on a tripod, connecting the air and water hoses, and drilling for seven minutes, this period including the time required for setting up. Ten teams were entered.

It happened that the first team selected an Ingersoll-Rand DA-35 drifter from among the three drills available and that it made such a good showing that all the other teams elected also to use it. The results according reflected not only the performance of the machine, but also the varying skill of the several teams in operating it. The DA-35 is a 154-pound machine, being classed as a lightweight drifter. It uses 1¼-inch hollow-round drill steel. The rock selected for the contest was the hardest granite that could be obtained in the locality. While the time required for getting ready to drill varied among the different teams, it averaged around 30 to 35 seconds, so that the actual drilling time was approximately 6½ minutes. Included in this was the time required to change steels.

The winning team was composed of John Bonetto and Hans Scheiffle, who drilled 63.6 inches, or an average of about 9.8 inches per minute for the 6½ minutes of actual drilling time. The three next highest, with their drilling performances, were: Victor Johnson and Lawrence Naef, 58.50 inches; Jacob Schneider and Robert Moore 52.75 inches; and George Kjildsen and John Dotson, 52.25 inches. All of these marks were considered very good in view of the extreme hardness of the rock.

Two New "Slushing" Accessories

TWO NEW accessories of the scraper or "slushing" process of loading ore underground have been put on the market by Harley A. Coy of Mascot, Tenn. These are designated as the Mascot split-hook sheave, and the Mascot "Saflex Wedgeye."

As its name indicates, the sheave has a split or divided hook that can be opened on hinges at its base. This makes it possible to place the slushing cable over the sheave wheel without removing bolts or pins. Considerable time is saved by this, and as no parts can be lost or mislaid there can be no delays while they are being found. As broken ropes are often tied instead of being spliced, the wheel has been designed so that knots will pass over it. The sheave is riveted into a rigid unit, which prevents return ropes from twisting and sawing as they can do when sheaves with swivel-type hooks are used. Of cast steel construction, the sheave has been strengthened where failures usually occur. Either a sealed, greased-for-life ball bearing or a bronze bearing arranged for Alemite greasing can be had.

The "Saflex Wedgeye" is a quick and effective means of providing an anchorage for the sheave wheel. It consists of a short length of wire rope cable, to one end of which is fastened the eye, and to the other a cylindrical metal part. The latter is inserted in a hole drilled in the rock and is secured fast by driving in beside it a metal wedge that fits against a tapered flat surface on one side of the cylinder.

All bending and shock stresses are taken up in the short length of rope, which lessens the chance of the wedge working loose. As this rope can be of any length desired, anchor holes may be drilled well back of the working face, in firm ground. This flexible mooring also permits the sheave to adjust itself to the angle of the pull line and this reduces wear on the cable.

Mr. Coy, who developed these appliances, is superintendent of mines for the American Zinc Company. Both products have been given thorough tests in actual service in that concern's properties at Mascot, and it was because of their success there that it was decided to make them available to other mining companies.

Bridge Erection Filmed

A 16-mm. motion picture, "Building the Golden Gate Bridge" was released by Bethlehem Steel Company on October 10. It is a talking picture with a descriptive lecture on the sound track, and gives a complete story of the construction of the bridge, beginning with the arrival of the steel. Erection of the 746-feet-high steel towers that support the cables, and construction of the superstructure for the roadway of the 4,200-foot suspended span are depicted in detail. Of particular interest are the many special methods required in handling the steel because of the great size of the structure.

Many difficult construction problems had to be solved and the methods used are discussed in the descriptive lecture. While it is possibly of greatest interest to groups of engineers and others connected with the construction industry, the picture has sufficient dramatic appeal in many of the scenes to make it attractive to the layman as well.

Unique Tunnel Driving

THE YERBA Buena Tunnel, by which the San Francisco-Oakland Bay Bridge structure makes its way through a rocky island that divides the over-water sections, has the largest section of any bore yet built. It is 79 feet wide at the spring line, more than 57 feet high in the center, and 540 feet long. The method of constructing it was unique, the concrete sidewalls and arch that constitute its lining being placed before the central core of rock was removed.

The first excavation consisted of driving 14x14-foot drifts at the base of each sidewall line to the full length of the tunnel. These were then stoped to a height of 40 feet, after which the sidewalls were poured. Excavations for the arch ring were then made, the muck being dropped into the space inside the sidewalls. To support the roof until the concrete arch could be placed, 16-inch H-beams were set on 3-foot centers, their lower ends being supported by the central core. After the bore had thus been completely lined, the interior portion was excavated.

This method was followed not only to facilitate the progress of the work, but also to promote safety. The result was that there were only 21 lost-time accidents and 897 lost man-days out of a total of 288,710 man-hours of work. The tunnel was designed by the California Department of Public Works and was constructed, under contract, by T. E. Connolly.

A Notable Viaduct

THERE was recently completed and put in service in New Zealand a bridge or viaduct 911 feet long and more than 300 feet above the bed of the Mohaka River, across which it carries the tracks of the East Coast Railway. The structure contains 1,850 tons of steel, bound together by 450,000 rivets. Construction difficulties that were presented by the gorge that is spanned were overcome by erecting two aerial cableways. These extended between towers on either side of the chasm and handled all materials. The legs of the fabricated steel towers that support the viaduct rest on concrete piers, some of which were sunk to a depth of 70 feet below the surface of the swiftly flowing stream. The structure has been designed to withstand earth tremors and the violent storms that visit the section.

Industrial Notes

China, one of the principal world producers of tungsten, is reported to have prohibited the export of that metal for the duration of the hostilities with Japan.

The American Gas Association reports that the consumption of gas fuel in industry and commerce is now at an all-time peak. It has been steadily increasing since 1932 and for the year ended in June 1937 was 16 per cent greater than in the preceding year.

With the setting up of the air locks for the sinking of a pilot shaft, preliminary work has been begun on the new Thames River Tunnel in London. It will have a length of more than a mile, including approaches, and is estimated to cost $16,000,000.

Within the next five years Russia is planning to build five power stations in which shale is to be burned for steam-raising purposes. Two such plants are already in operation—one on the Volga and the other at Leningrad, bringing the total up to seven with a capacity of 530,000 kw.

New or old floors or stair treads of wood, concrete, steel, or stone, whether in wet or in dry locations, can be made slip-proof it is claimed by the use of Fut-Sure, a surfacing material that has recently been improved upon by making it waterproof. It is dark red in color and is applied with a trowel.

Calbar Paint & Varnish Company is offering a new compound for sealing joints in water, steam, oil, gas, or air pipes against leakage. The material is suitable for both threaded and gasketed connections. It is a combination of oils and pigments put up in paste form and sold in containers ranging in size from ½-pint cans to 50-gallon drums.

Bronze bearings that contain sufficient lubricating oil to last them in most cases throughout their normal service life are produced by the Keystone Carbon Company. They are molded of bronze powder and are impregnated in course of manufacture with a standard general-purpose lubricant unless the user specifies a special kind. Plain or flanged bearings of any size and shape that lends itself to molding can be made and held to close tolerances.

Molybdenum is now being used in the electrodeposition of zinc on iron and steel in a special process developed by the Grasselli Chemicals Department of the E. I. du Pont de Nemours & Company. It is claimed that the addition of this element to the plating solution produces a coating of superior qualities and creates plated work having all the virtues of cadmium plate, plus a bright finish.

Virtually all the railroad system of Switzerland is now electrified, there is scarcely a village in the country without electric service, and many hotels and private homes cook with electricity. The source of this power is the interconnected chain of hydroelectric generating stations, made possible by the abundance of water from the glaciers and snow fields.

To promote interest in mining, the Department of Mines and Resources of Canada has recently completed a 6-reel motion picture, "Unlocking Canada's Treasure Trove." It depicts all operations of gold production, beginning at the shaft house and ending with the dispatch of refined gold bullion to the royal mint. The scenes were photographed at some of Canada's best known mines and the finished picture resulted from editing 20,000 feet of film.

It is reported that the Association of American Railroads will build for experimental purposes a locomotive powered by a steam turbine. It will operate with steam at 1,250 pounds pressure which is to be developed in oil-fired boilers of special type. The turbine will be rated at 4,000 horsepower and is expected to use less than nine pounds of steam per horsepower per hour. The power will be transmitted directly from the turbine to the driving wheels. It is anticipated that the locomotive will attain a maximum speed of 120 miles per hour.

No one has ever attempted to estimate the annual cost to industry of leaky pipe lines, but the loss is tremendous. Depending upon what is being passed through a pipe, a leak the size of a pinhole may cause great damage and may even constitute a hazard to persons and property. As a consequence of these things, the repair of leaky lines assumes considerable importance. In a new *Pipe Line Repair Book* published by M. B. Skinner & Company of South Bend, Ind., full discussion is made of various pipe line failures and a method of repairing leaks without discontinuing service is disclosed. The handbook is offered free to those responsible for pipe line maintenance.

An improved apparatus for spraying molten metal is announced by the Metals Coating Company of America. It is designated as the Majestic Metalayer and it is claimed that it will deposit approximately double the amount of metal as other similar appliances while consuming only about one-third as much oxygen and acetylene per weight of metal deposited when using the larger size of wires. It uses compressed air at pressures of from 55 to 70 pounds, depending upon the type of metal being sprayed and the size of the wire that is melted. The pressure range of oxygen and acetylene is from 8 to 15 pounds.

In testing the relative strength of various building materials, it was determined that Celotex Vapor-seal sheathing was 28 per cent stronger than diagonal wood sheathing and 330 per cent stronger than horizontal wood sheathing. The latter failed under a pressure of 2,700 pounds; the diagonal sheathing when 6,450 pounds pressure was applied; and a 4x8-foot panel of Celotex, nailed to conventionally spaced wood studs 4 feet long, resisted a maximum lateral tensile stress of 8,940 pounds before breaking. The investigations were made in the Civil Engineering Testing Laboratories of Columbia University.

The ballast-filled spaces between railroad ties are known as cribs. The crib material becomes consolidated in time and when the ballast is to be cleaned, it must be dug out. When done by hand, this is a slow and costly procedure. A new cribbing fork that may be operated by a pneumatic tie tamper has been announced by Ingersoll-Rand Company, 11 Broadway, New York. Tests show that two men using these tools can loosen ballast as fast as six men can shovel it out. When working entirely by hand, a man with a pick is required for each shoveler. The new cribbing fork is made to fit three sizes of tie tampers, and is described in Form 2357.

SKF Drill Steel is the title of a 44-page, well-illustrated pamphlet that has recently been released for free distribution by A. B. SKF Hofors Bruk of Sweden. It is a practical book written for practical men, and both the buyer and the user will find in it much useful information and many helpful pointers. Among other data, it contains tables giving the dimensions, sections, and weights of its hollow and solid rock-drill steel; instructions on how to forge and to heat treat it; and tells how to get the most out of steel. Copies may be obtained from SKF Steels, Inc., 369 Lexington Avenue, New York, N. Y.

Norma-Hoffmann Bearings Corporation, Stamford, Conn., has issued a new catalogue, F-958, describing its complete line of precision ball, roller, and thrust bearings. It is a book of 84 pages and contains, in addition to tables covering sizes, dimensions, and load ratings of 108 distinct series of standard precision bearings, much valuable engineering data, including cross-sectional drawings of typical applications of bearings of various types; full bearing tolerances; instructions for mounting, lubricating, and protecting bearings; and recommended dimensions of housings, shafts, and shaft shoulders. A copy of the catalogue may be obtained from the company upon request.

Mist Checks Dust and Fumes at Mine Headings

AT HEADINGS in mines and tunnels it is good practice, according to Capt. P. S. Hay, British Inspector of Mines, to deal with the dust and nitrous fumes following shot firing at the source of production rather than to carry them from one place to another by circulating air. As a substitute he recommends the use of a mist projector with which experiments have been conducted in England for several years.

The device, details about which are lacking, is essentially an atomizer attached to the end of an air hose, and the liquid applied is said to be a weak solution of washing soda. As soon as the fuses are lighted, the air supply is turned on, and about 5 gallons of the solution is sprayed toward the face, the fine mist spreading out in the shape of a cone under the impulse of the compressed air and meeting the oncoming dust and fumes, effectually neutralizing them.

After the tank containing the liquid has been emptied, the air is allowed to flow for some minutes. This serves to clear the heading of any residual mist that might otherwise cause the working to become wet. Slight dampness, it has been found, does not affect the roof, sides, or floor, nor cause any appreciable rise in humidity. The device works best where the ventilation is sluggish, because it takes a definite period for the particles of moisture to contact the particles of dust so that the latter will cling to one another and fall to the floor. Ventilating systems that create a good circulation of air should therefore be slowed down until the spraying operation is finished.

In discussing the mist projector at a meeting of the Lancashire Branch of the National Association of Colliery Managers, it was brought out that it has been used with encouraging results in coal mines at drifts and headings where blasting was going on, as well as at underground loading stations—at points along conveyor systems where the coal is dumped into buckets. The latter application was made with an improvised apparatus in the Ince Moss collieries of the Wigan Coal Corporation, and is said to have dealt effectually with the very fine dust. Experiments conducted in the Coal Owners' Research Laboratory at Birmingham proved that from 90 to 95 per cent of the coal dust suspended in the air in thick clouds, corresponding to that obtaining at gate-end loaders, could thus be checked.

Compressed air is the only satisfactory means with which to do the spraying, and is generally available for the purpose. Where that is not the case, a small compressor, capable of delivering from 100 to 150 cfm. at not less than 60 pounds pressure per square inch, will generally be adequate and will help to bring about more healthful conditions at mine headings.